FRACTURES OF THE JAWS

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Third Edition, Thoroughly Revised
Illustrated with 199 Engravings



LEA & FEBIGER
PHILADELPHIA

PRINTED IN U S A

TO

VILRAY PAPIN BLAIR, A M , M D , F A C S

TO WHOM WE OWE

AN ETERNAL DEBT OF GRATITUDE

AS TEACHER, COUNSELLOR AND FRIENDLY CRITIC

THIS BOOK IS RESPECTFULLY DEDICATED

PREFACE TO THE THIRD EDITION

In offering this, the Third Edition, the authors are fully appreciative of the continued popularity of this book In this edition a few changes have been made but the general character of the text remains the same Several additional methods of treatment of fractures of the jaws have been described, all of which have been found useful in certain cases With few exceptions, the methods described in the text have proven satisfactory in the hands of the authors

A number of new illustrations have been added and for their use the authors wish to thank *The Journal of Oral Surgery,* published by the C V Mosby Company, and the W B Saunders Company Dr F Risdon and Dr Matthew Federspiel have also furnished illustrations and the authors are grateful for their courtesy in supplying them

R H I
L C

Philadelphia, Pa

PREFACE TO THE FIRST EDITION

This book contains the results of many years experience in the treatment of fractures of the jaws and their complications The methods advocated are those which in the hands of the authors have proved most successful It is hoped that this presentation will appeal to the surgeon, the specialist and the dentist The general surgeon may feel that the details of treatment of fractures of the jaws do not concern him But as long as cases are admitted to his service in the hospital, it is his responsibility to see that they receive proper treatment, either by himself or by someone delegated by him who understands the problem The haphazard way in which these fractures are frequently handled at present is often a cause of permanent crippling of the function of the jaw, unless correction is undertaken by measures requiring many additional months of treatment One great advantage of the methods advocated is that they can be employed by surgeon, oral surgical specialist, or dentist immediately, regardless of the case, without resort to highly technical dental laboratory procedures, so that practically no time is lost in reduction and fixation of the fragments The numerous illustrations, most of them original, should simplify the carrying out of the methods described

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FRACTURES OF THE JAWS

CHAPTER I

ANATOMICAL CONSIDERATIONS

THE UPPER JAW

THE upper jaw, from a surgical standpoint, includes the right and left maxillæ, portions of the ethmoid and sphenoid bones, and all the bones of the face except the mandible two malar, two nasal, two palate, two lacrymal, two inferior turbinates and the vomer

From an anatomical standpoint, it consists of the maxilla and its fellow of the opposite side, for convenience referred to as one bone It is a very irregular bone forming the front of the upper part of the face and the floor of the orbit, much of the outer wall and floor of the nasal fossa and most of the hard palate, and it supports all of the maxillary teeth and contains the maxillary sinus or antrum of Highmore

To quote Cryer,[2] "It is situated beneath the walls of the anterior fossa of the brain case and rather loosely attached by what may be termed buttresses and flying buttresses In the center, near the nasion, the frontal processes rest firmly against a buttress in the median line, the maxillary process of the frontal bone Below is a flying buttress, the nasal septum, especially that portion formed by the vomer, which passes upward and backward from the interarticulating ridge of the maxillæ and palate bones to the buttress-like body of the sphenoid bone, where it is firmly held or braced in place by the vaginal process Laterally the upper jaw is supported through the zygomatic bones through the zygomatic processes of the frontal bone and the flying buttresses of the zygomatic arches to the temporal bones at the sides of the skull, posteriorly by the pterygoid processes of the sphenoid, with a portion of the palate bone interposed (Figs 1 and 2)

"The buttresses, situated and distributed as they are, not only afford support against forces acting externally, but also dissipate and diffuse shocks which would otherwise be transmitted to the cranium. As a consequence of its construction, but little force in a forward direction is necessary to detach the upper jaw from the cranium, though it will withstand a blow of great force received from below through the lower jaw or from in front, or even from the side"

The nasal bones, in their articulation with the maxillæ complete the anterior nasal orifice The lacrymals and ethmoid touch the inner side of the orbital plate, and the ethmoid the inner surface of the nasal process The inferior turbinate rests on the inner surface of the maxilla within the nasal fossa

The under surface of the upper jaw is bounded by the alveolar process and the palatal processes forming a portion of the roof of the mouth (Fig 3)

The alveolar process is made up of two plates, an external, which extends upward and merges with the outer surface of the true maxilla, and an

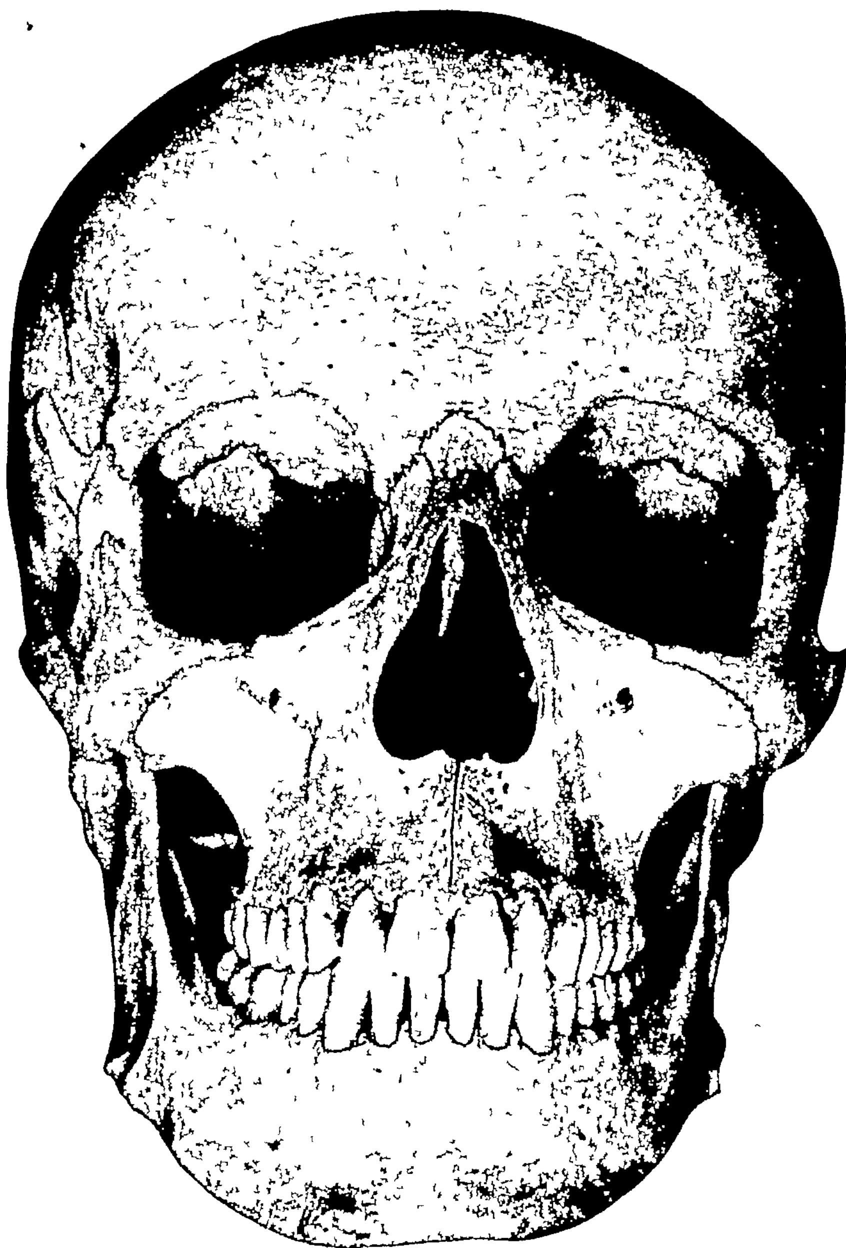


Fig 1 —Anterior view of the typical skull (Cryer)

internal, which extends upward to become continuous with the palatal process of the maxilla and the palate bones "The alveolar process belongs to the teeth and is developed with them for the purpose of holding them in position" It disappears after the teeth are lost The teeth will be considered at a later time in connection with their relation to those of the mandible



Fig 2 —The right side of the lower portion of face (Cryer)

Fig 3 —Anterior portion of the base of a typical skull (Cryer)

The *sutures* of the roof of the mouth are seven in number In fractures of the upper jaw the bone often separates through one or more of these sutures "The median palatal suture begins at the postnasal spine, passes forward between the palate bones, then between the true maxillæ to the incisive foramen, then forward between the premaxillæ to terminate at the anterior nasal spine It is divided into three sections, the interpalatal, the intermaxillary, and the interpremaxillary sutures There are four transverse sutures, two situated between the palate bone and the palatal processes of the maxillæ, and two pass outward from the incisive foramen between the maxillæ and the premaxillary bones to pass also between the canine teeth and the second incisors" (Cryer).



Fig 4

The *maxillary sinus,* or *the antrum of Highmore* (Fig 4) is a large air cavity within the bone, quite variable in size but conforming in a general way to the shape of the bone The floor often contains elevations over the roots of the teeth, the molars in particular, less frequently the premolars, and rarely the canines The roof of the sinus is the floor of the orbit Its surface is usually marked by a ridge which contains the groove for the passage of the infraorbital vessels and nerve This groove occupies the posterior half of the floor of the orbit and at about the middle passes into the infraorbital canal The ostium maxillare, usually found at the upper anterior portion of the nasal wall, affords communication between the sinus and the middle meatus of the nasal cavity through the hiatus semilunaris Fractures of the upper jaw may involve one of the walls of the antrum, causing hemorrhage or infection of this cavity

Muscle Attachments —There are no muscles attached to the upper jaw which can cause or perpetuate deformity in case of injury, such as fracture

Hence, when the fragments are once replaced they tend to retain their position

Vascular Supply.—The maxilla is exceedingly vascular, hence, the healing of any injury, no matter how severe, is apt to be rapid and complete The main blood supply comes from the external carotid through one of its terminal branches, the *internal maxillary* (Fig 5) This artery is a large branch arising from the anterior aspect of the external carotid beneath the neck of the condylar process of the mandible It passes forward,

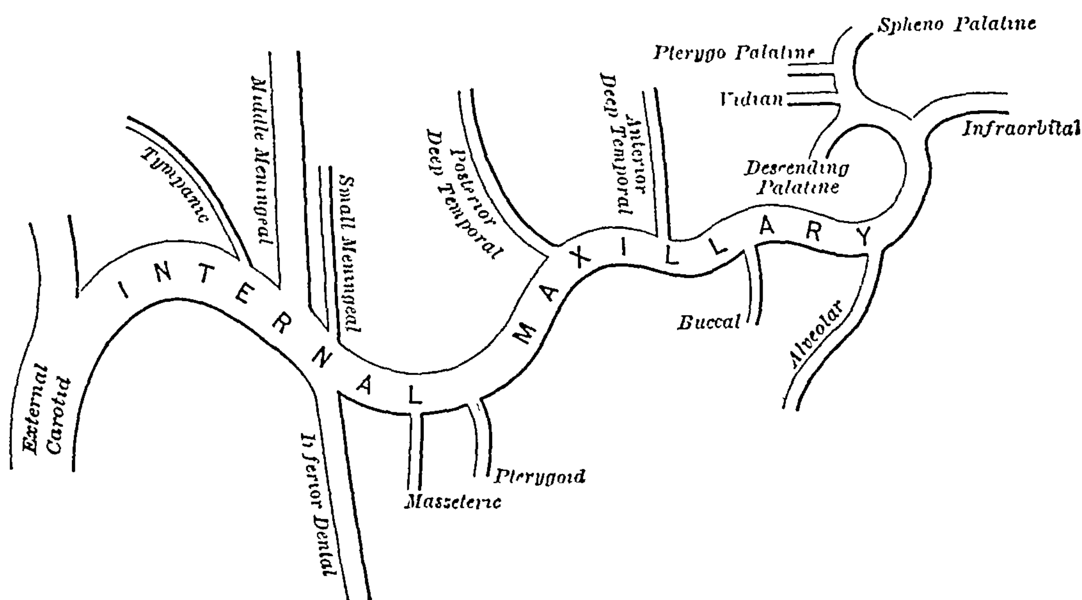


FIG 5 —Internal maxillary artery (Testut)

through the two heads of the external pyterygoid muscle and enters the pterygopalatine fossa, thence passes through the sphenopalatine foramen as the sphenopalatine artery It is customary to divide the internal maxillary artery into three divisions The first, or mandibular portion, lies internal to the neck of the condyle, and gives off branches to the ear, into the brain case and through its terminal branch supplies the lower jaw and teeth through the mandibular or inferior alveolar The second or pterygoid portion, is that which traverses the zygomatic fossa and which gives branches to the adjacent muscles of mastication The third or sphenomaxillary portion, gives off branches which are the main supply to the maxilla (*a*) The superior alveolar branch descends upon the tuberosity of the maxilla giving off small branches which penetrate small foramina in that bone and are distributed to the molar and premolar teeth and gums (*b*) The infraorbital artery passes through the pterygopalatine fossa and foramen to traverse the infraorbital groove and canal to emerge on the face at the infraorbital foramen where it divides into the palpebral, nasal and labial arteries Within the infraorbital canal it gives off branches to the eye, and anterior dental branches which pass down the anterior wall of the maxillary sinus to supply the mucous membrane of the sinus and the canine and incisor teeth (*c*) The descending palatine artery passes through the posterior palatine canal and following its emergence

from the posterior palatine foramen divides into an anterior and a posterior branch The former passes forward beneath the mucous membrane of the hard palate, which it supplies, to anastomose with the sphenopalatine artery The latter passes backward to supply the soft palate and tonsil (*d*) The vidian and (*e*) the pterygopalatine arteries are small branches which in turn send branches to the roof of the pharynx (*f*) The sphenopalatine artery is the terminal branch of the internal maxillary It passes into the nasal cavity through the sphenopalatine foramen and divides into an internal and an external branch The internal, or nasopalatine branch passes forward, giving branches to the septum of the nose, and finally passes downward through the anterior palatine or incisive foramen to anastomose with the anterior branch of the descending palatine The external branch ramifies over the lateral wall of the nasal fossa

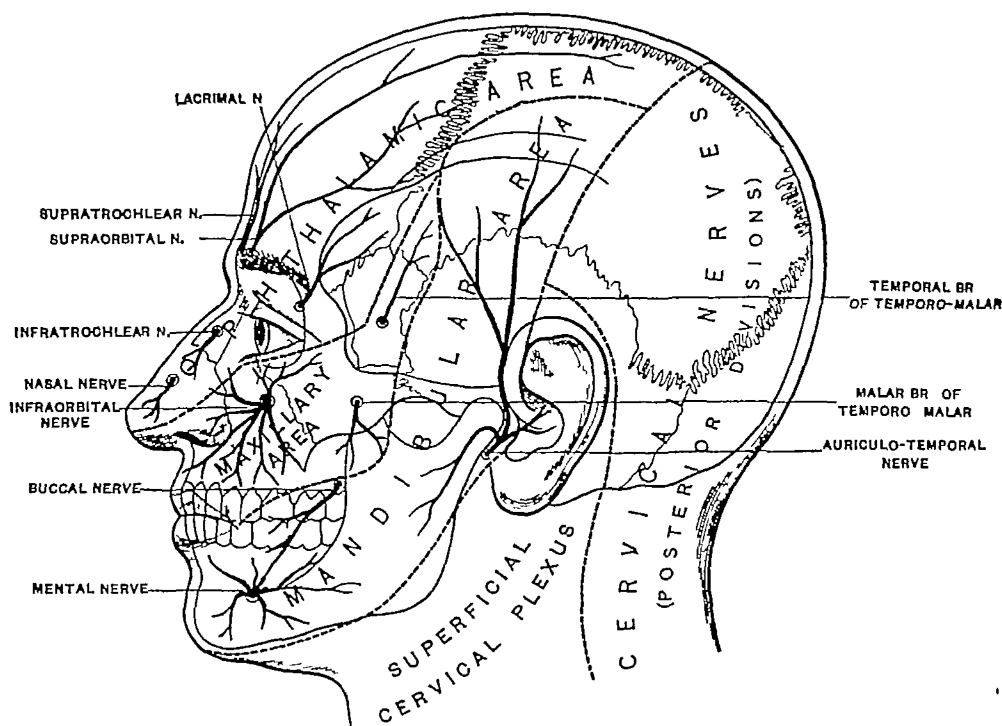


FIG 6 —Sensory areas of head, showing general distribution of the three divisions of the trigeminal nerve (Modified from Testut)

Sensory Nerve Supply.—The *maxillary*, or *second division of the fifth cranial* (*trifacial or trigeminal*) *nerve* supplies sensation to essentially all the structures of and about the maxilla (Figs 6, 7 and 8) It arises from the middle of the anterior border of the Gasserian ganglion, passes forward and leaves the cranium through the foramen rotundum in the great wing of the sphenoid bone It then traverses the pterygopalatine fossa and enters the infraorbital groove and canal and finally emerges on the face along with the infraorbital artery through the infraorbital foramen

Branches are given off from the maxillary nerve in the cranium, the pterygopalatine fossa, the infraorbital canal, and on the face (1) Within the cranium the recurrent branch supplies the dura mater in the middle

cranial fossa Arising in the pterygopalatine fossa are the (2) sphenopalatine branches which supply the sensory root of the sphenopalatine (Meckel's) ganglion, and the (3) posterior-superior dental nerve which passes along with the posterior-superior dental artery through the pterygomaxillary fissure to supply the gums and adjacent mucous membrane of the cheek and finally enter the posterior dental canals to supply the molar teeth It forms a rich plexus with the middle and anterior-superior dental nerves (4) The temporomalar or orbital nerve also arises from the maxillary in the pterygopalatine fossa and passes into the orbit through the pterygopalatine fissure (5) The middle-superior dental nerve arises from the maxillary in the posterior portion of the infraorbital canal, and passes downward in a canal in the outer wall of the antrum to supply the premolar teeth (6) The anterior-superior dental nerve is the largest of the superior dental nerves and leaves the maxillary just before the exit of the latter at the infraorbital foramen to descend in a canal in the anterior wall of the antrum It gives off branches to supply the mucous membrane of the floor of the nose and after helping to form the superior dental plexus supplies the canine and incisor teeth

The maxillary becomes the infraorbital nerve in the infraorbital canal and after its emergence from the infraorbital foramen gives off (7) inferior palpebral branches to the lower eyelid, (8) lateral nasal branches to the skin of the side of the nose, and (9) superior labial branches to supply the anterior portion of the skin of the cheek, the mucous membrane and skin of the upper lip These last three branches inosculate freely with the infraorbital branch of the facial nerve to form the infraorbital plexus

It can be readily understood that in fractures of the upper jaw, which involve the infraorbital canal and foramen, there is often a numbness of the anterior part of the cheek and side of the nose, the upper lip and the anterior teeth, with the adjacent mucous membrane and gums

Sphenopalatine Ganglion (Fig 7) —The sphenopalatine ganglion, also known as *Meckel's ganglion,* is one of a series of three sympathetic nodes connected with the trigeminal nerve It is situated in the upper portion of the pterygopalatine fossa beneath the maxillary branch of the trigeminal The sensory root consists of the sphenopalatine nerves, just described The motor root is the great superficial petrosal nerve from the facial which joins the sympathetic root, the great deep petrosal from the carotid plexus, over the cartilage of the middle lacerated foramen to form the vidian nerve This nerve traverses the canal of the same name to enter the pterygopalatine fossa and join the sphenopalatine ganglion The ascending branches pass essentially to the region of the orbit The descending branches are the large and small posterior palatine and the accessory posterior palatine nerves The large posterior palatine nerve passes downward through the pterygopalatine canal, in which it gives small branches to the nasal fossa, to emerge from the pterygopalatine foramen and passes forward in a groove on the inferior surface of the hard palate to inosculate with the terminal branches of the nasopalatine It supplies the hard palate and its mucous membrane, also the inner side of the gums

The small posterior palatine nerve passes downward through a small canal to supply sensory fibers to the soft palate and tonsil, and motor fibers to the levator palati and azygos uvulæ muscles. The accessory

SPHENO-PALATINE BRANCHES
LACHRYMAL NERVE
GASSERIAN GANGLION
SUP
MAXILLARY NERVE
TEMPORAL
MALAR
VIDIAN NERVE
MECKEL S GANGLION
PALATINE BRANCHES
POSTERIOR DENTAL
INFRAORBITAL BRANCHES OF FACIAL
INFERIOR PALPEBRAL
LATERAL NASAL
INFRAORBITA
SUPERIOR LABIA

Fig 7 —Maxillary division of trigeminal nerve and Meckel's ganglion (Testut)

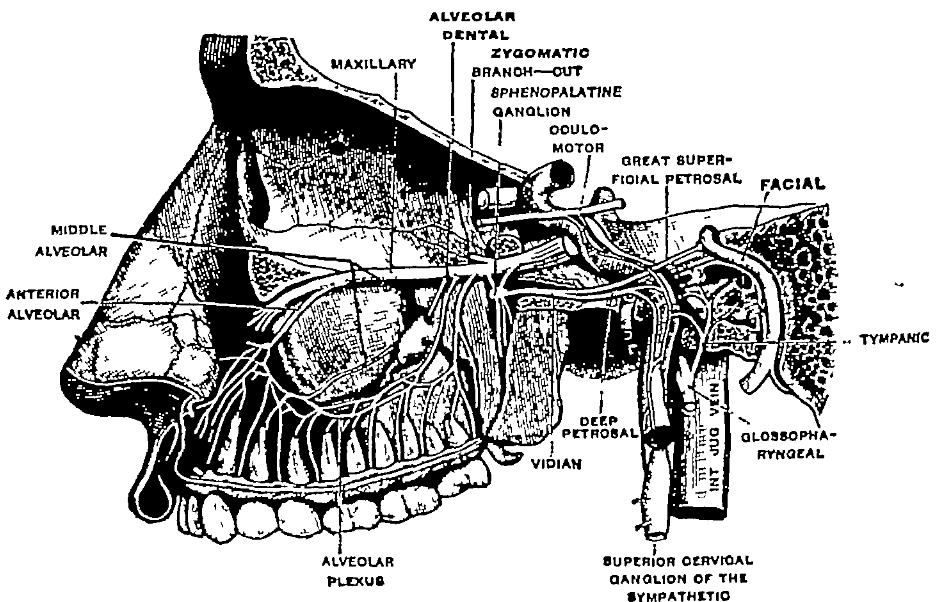


Fig 8 —Dental branches of maxillary nerve and sphenopalatine ganglion (Modified from Testut)

posterior palatine nerve passes through the canal of the same name to also supply sensation to the soft palate and tonsil

The internal branches are the posterior-superior nasal which supplies the posterior outer wall of the nasal fossa, and the nasopalatine nerve, which crosses the roof of the nasal chamber and passes downward to reach the anterior palatine canal It then passes through the foramen of Scarpa, the left nerve through the anterior and the right nerve through the posterior canal, and having reached the inferior surface of the hard palate inosculates with the large posterior palatine nerve The posterior branch supplies the mucous membrane of the upper portion of the naso-pharynx

THE LOWER JAW

The lower jaw or *mandible* is the only bone of the skull which is movable on the others. It develops in two symmetrical halves which fuse at a point known as the symphysis The bone consists of a body, forming the chin and supporting the teeth, and two rami, projecting upward from the back on either side and articulating with the mandibular fossa of the temporal bone (Fig 9)

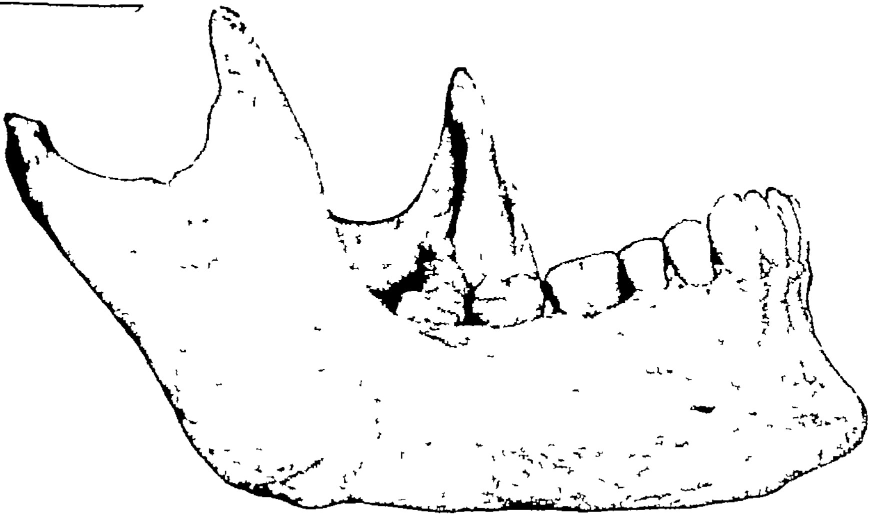


Fig 9 —Side view of mandible (Cryer)

The body is convex in front and concave behind A short distance laterally from the symphysis and at the lowest border of the body is a projection, the mental tubercle The *mental foramen*, for passage of the terminal branches of the mandibular nerve and vessels, is about in the middle of the outer surface of the bone vertically and usually between the first and second premolar teeth The bone is frequently fractured through this opening The external oblique line starts from the mental tubercle and passes backward beneath the mental foramen into the anterior border of the ramus The mylohyoid line (Fig 10) begins near the genial tubercles, which are sharp bony spines near the lower part of the inner side of the symphysis for muscle attachments, and passes backward to disappear on the inner side of the ramus It gives attachment to the mylohyoid muscle, which forms the main support for the floor of the oral cavity The alveolar

process for supporting the teeth is above the body, and, as in the upper jaw, undergoes resorption after loss of the teeth

The ramus joins the body at an angle of from 110 to 140 degrees in the adult, and is a four-sided plate with outer and inner surfaces The junction

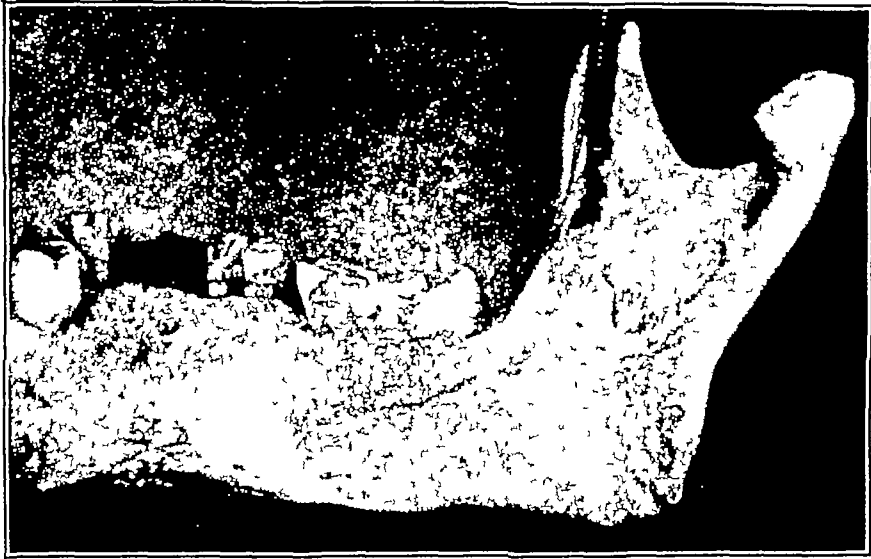


Fig 10 —Inner surface of right half of mandible

of the posterior and inferior borders is called the angle The inner aspect of the ramus at this point is roughened for the attachment of the internal pterygoid muscle About on a line with the free edge of the alveolar

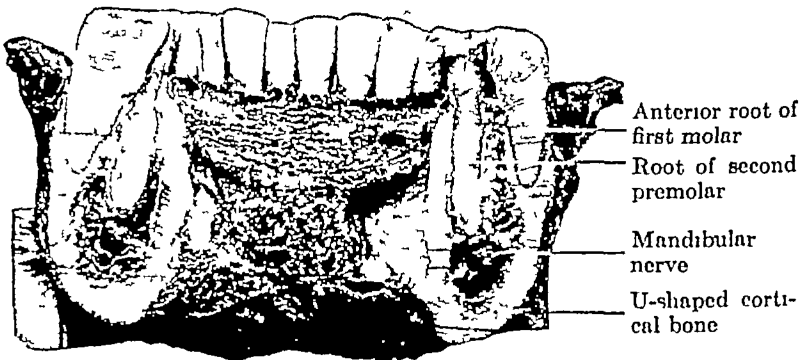


Fig 11 —Transverse section of mandible, showing U-shaped layer of cortical bone (Cryer)

process and near the mid-portion of the inner surface of the ramus, is the mandibular foramen, an opening into the mandibular canal which courses forward into the body of the bone The foramen is guarded in front by a sharp projection, the lingula

The anterior border of the ramus is thick below and narrow above, where it projects upward and slightly outward as the coronoid process for attachment of the temporal muscle The outer border of the thick lower part is made by the external oblique line, the inner border by a continuation of the alveolar ridge and the mylohyoid line The posterior border

slants upward, backward and a little outward, and above widens to form the back of the head or condyle The latter presents an articular surface, convex from before backward The neck is a constriction below the head and is a frequent site for fractures Between the condyle and the coronoid process is a deep depression, the mandibular notch

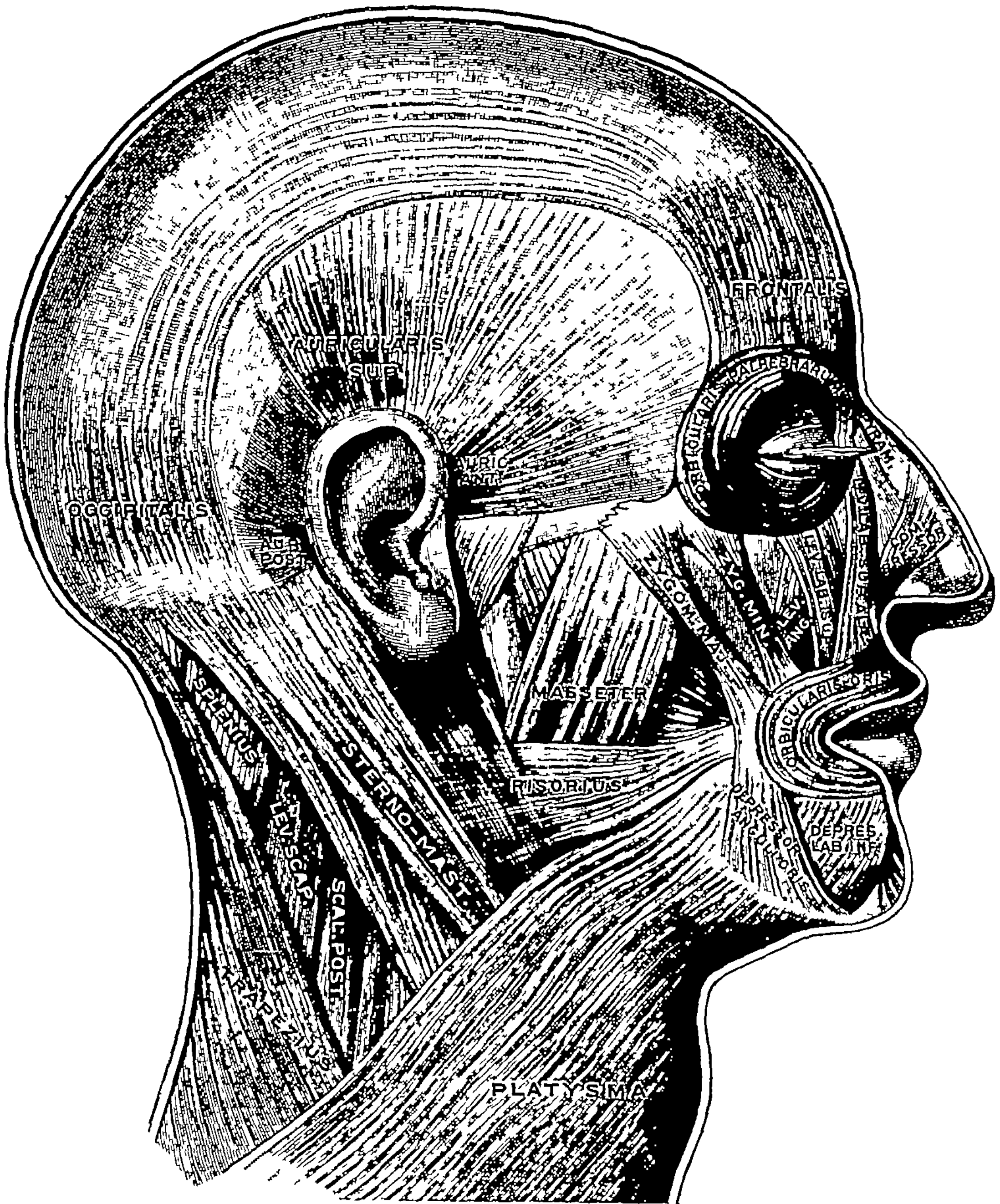


Fig 12 —Superficial muscles of head and neck (Testut)

The mandibular canal courses downward and forward in the ramus, then runs horizontally forward in the body It divides about under the second premolar tooth into the mental canal running to the mental foramen, and the incisive canal, quite small, which carries the nerves and vessels to the anterior teeth and is lost in the cancellated tissue

The exposed position of the mandible renders it unusually liable to fracture, but it is to a great extent protected by its horseshoe-shape which gives it some of the properties of a spring, by its density of structure, by its great mobility and by the buffer-like articular cartilages that protect its attached extremities (Treves) The lower jaw is a very tough bone, especially at the symphysis, where it is almost solid It consists of an outer U-shaped layer of cortical bone and an inner portion of cancellous bone (Fig 11)

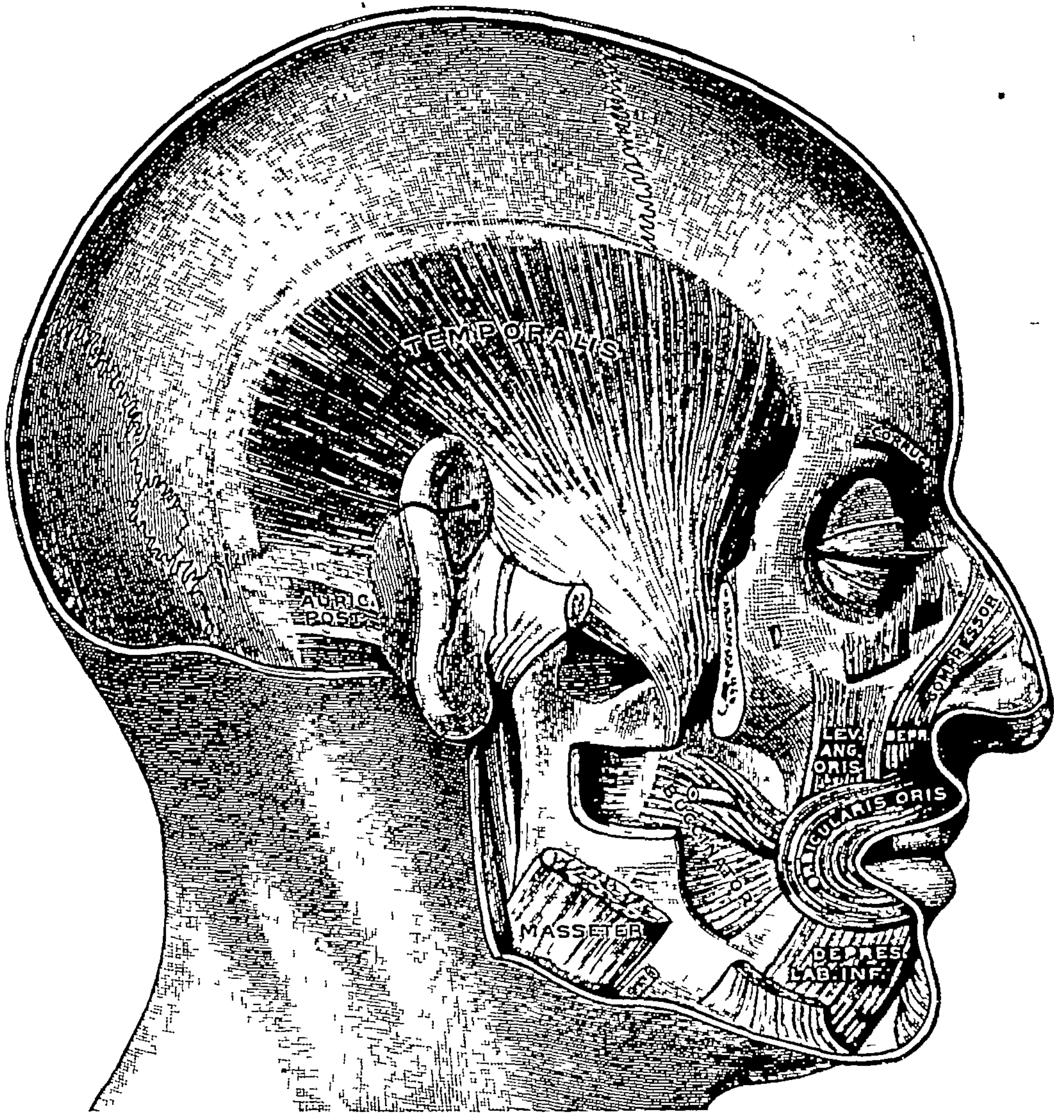


Fig 13 —Temporal and deep muscles about mouth (Testut)

Muscle Attachments of the Mandible —The deformity and displacement, which are to be found in the majority of fractures of the mandible are due to the action, or the interaction of the various muscles attached to the mandible These may be roughly grouped under two heads, the *elevators* and the *depressors* The former group embodies the masseter, the temporal and the internal pterygoid

The *masseter* (Fig. 12), a strong quadrilateral muscle arising by two heads from the zygoma, finds insertion in the outer surface of the angle of the mandible and into the outer surface of the ascending ramus as high up as the bases of the coronoid and condyloid processes

The *temporal muscle* (Fig 13) arises in the shape of a fan from the deep layer of the temporal fascia and the whole extent of the floor of the temporal fossa, and is inserted into the coronoid process, practically enveloping the process with its attachment

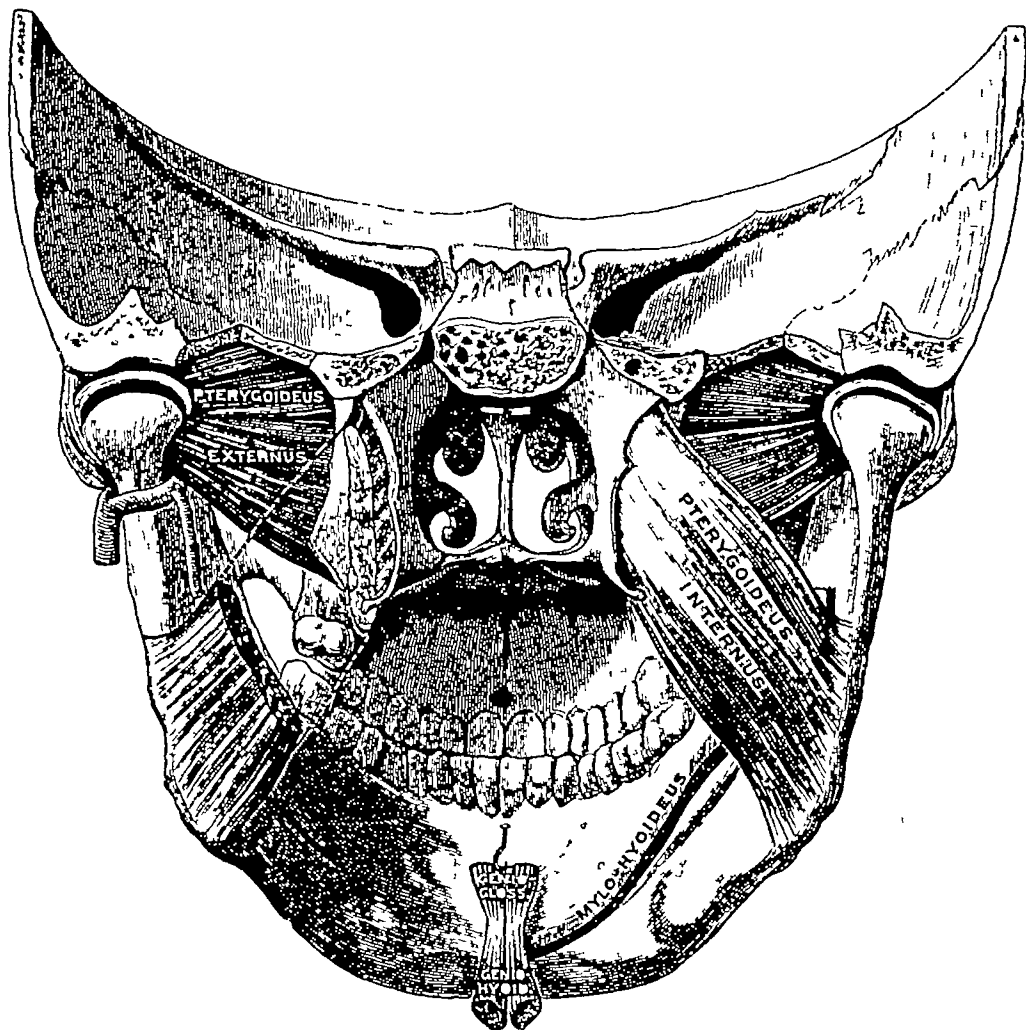


FIG 14 —Pterygoid muscles, viewed from behind (Testut)

The *internal pterygoid* (Fig 14) arises for the most part from the floor and walls of the pterygoid fossa with occasional fibers from the tuberosity of the maxilla and adjacent palate bone The fibers are inserted into the inner surface of the angle and ramus of the mandible below the mylohoid groove These three muscles all act to elevate the mandible

The *external pterygoid* (Fig 14) is placed here for convenience Strictly speaking, it belongs to neither elevator nor depressor group It arises by two heads The upper head arises from the under surface of the great wing of the sphenoid and the lower head arises from the outer surface of

the lateral pterygoid plate After allowing passage of the internal maxillary artery between the two heads, the latter unite to be inserted into the anterior border of the interarticular disk of the mandibular joint and into the neck of the condyle of the mandible When both muscles act they bring the lower jaw forward, when but one acts, there is a lateral excursion of the jaw

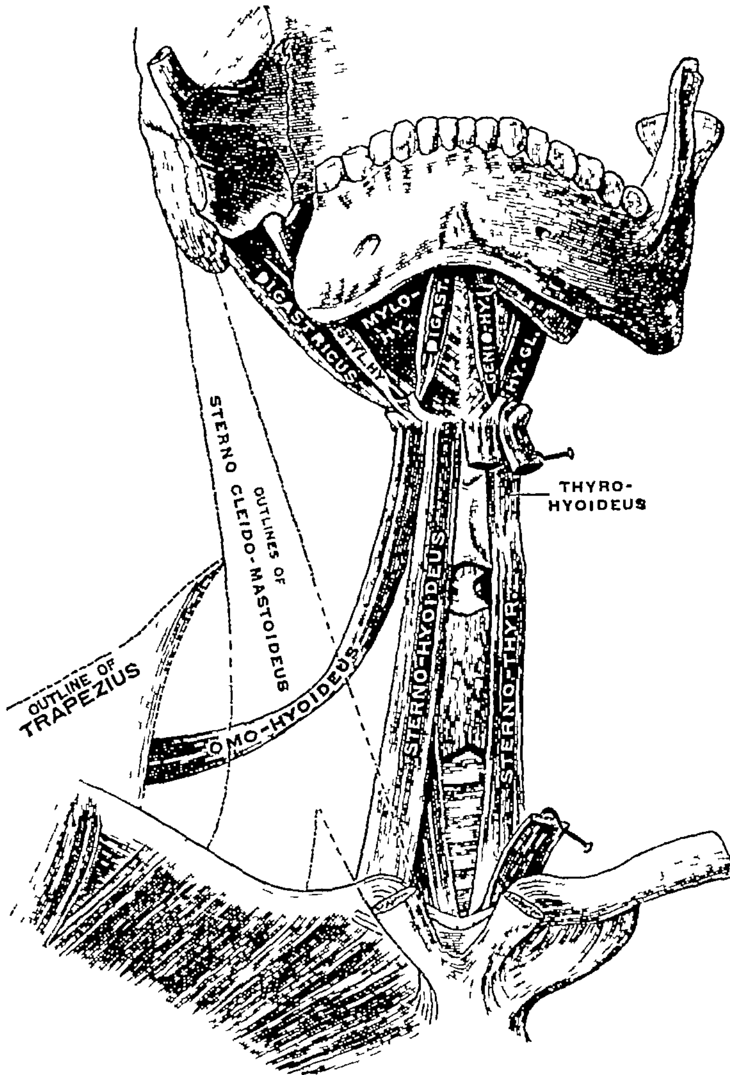


FIG 15 —Infrahyoid and suprahyoid groups of muscles (Testut)

All of the elevator muscles are innervated by branches of the anterior portion of the mandibular division of the fifth nerve The masseter and internal pterygoid muscles act as partial splints in fractures at or near the angle

The *depressors* of the lower jaw are the digastric, geniohyoid, genio-hyoglossus, mylohyoid and platysma (Fig 15)

The *digastric*, as the name implies, consists of two bellies, the anterior belly alone belonging to the group of depressors It arises from the digastric fossa on the inner surface of the body of the mandible anteriorly and inserts into the intermediate tendon, which is bound down to the hyoid bone by

a pulley-like band of cervical fascia The posterior belly arises from the mastoid groove of the temporal bone and passes forward to be inserted into the intermediate tendon

The *geniohyoid* arises from the lower genial tubercle of the mandible and is inserted into the body of the hyoid bone

The *geniohyoglossus* arises from the upper genial tubercle and the fibers pass backward in the shape of a fan, viewed from the side, to be inserted into the base of the tongue and the sides of the body of the hyoid bone

The *mylohyoid* arises from the entire length of the mylohyoid ridge of the mandible, from which the fibers pass inward, to be inserted, for the most part, into a median fibrous band common to the two muscles of the opposite sides The posterior fibers, however, are attached to the upper border of the hyoid bone This muscle, with its fellow, forms the muscular floor of the mouth

The *platysma* (Fig 12) is a superficial muscle arising from the skin and subcutaneous tissue over the pectoralis major and deltoid muscles on a line just below the clavicle, whose fibers are inserted into the body of the mandible from the symphysis to the insertion of the masseter

These muscles all depress the mandible and accordingly tend to cause a downward, backward and inward displacement of the fragments in fractures of the mandible, depending on their location

Vascular Supply.—The blood supply to the mandible is through the *mandibular artery* (Fig 5), which is given off from the lower aspect of the internal maxillary artery as it passes beneath the condyle of the mandible The artery courses forward and downward giving off small branches to the tongue and mylohoid muscle, and then entering the mandibular foramen traverses the mandibular canal, giving off branches to the lower teeth as it passes beneath them Just before emerging from the mental foramen as the mental artery, it gives off an incisive branch which supplies the incisor teeth and the canine The mental artery supplies the surrounding tissues and anastomoses with the inferior labial and submental branches of the facial

Sensory Nerve Supply —The *mandibular* branch of the fifth cranial, or trigeminal nerve, is the largest of the three divisions and consists of two portions, one motor and one sensory The sensory part is the larger and arises from the lower anterior part of the Gasserian ganglion This portion, along with the motor root of the fifth nerve, emerges from the skull as one trunk through the foramen ovale to separate under cover of the external pterygoid muscle into an anterior, or motor division and a posterior, or sensory division (Figs 16 and 17)

The anterior division gives off branches to the muscles of mastication (masseter, temporal, internal and external pterygoid), and to the anterior belly of the digastric, mylohyoid, tensor palati and tensor tympani

The posterior division passes downward under the external pterygoid muscle and, after giving off the auriculotemporal and lingual branches passes between the ramus of the mandible and the sphenomandibular ligament to enter the mandibular foramen The auriculotemporal nerve

passes upward through the substance of the parotid gland and ascends to the temporal region The lingual nerve passes inward, forward and downward under the mucous membrane of the floor of the mouth to supply the tongue, floor of the mouth and gums on the lingual aspect of the teeth

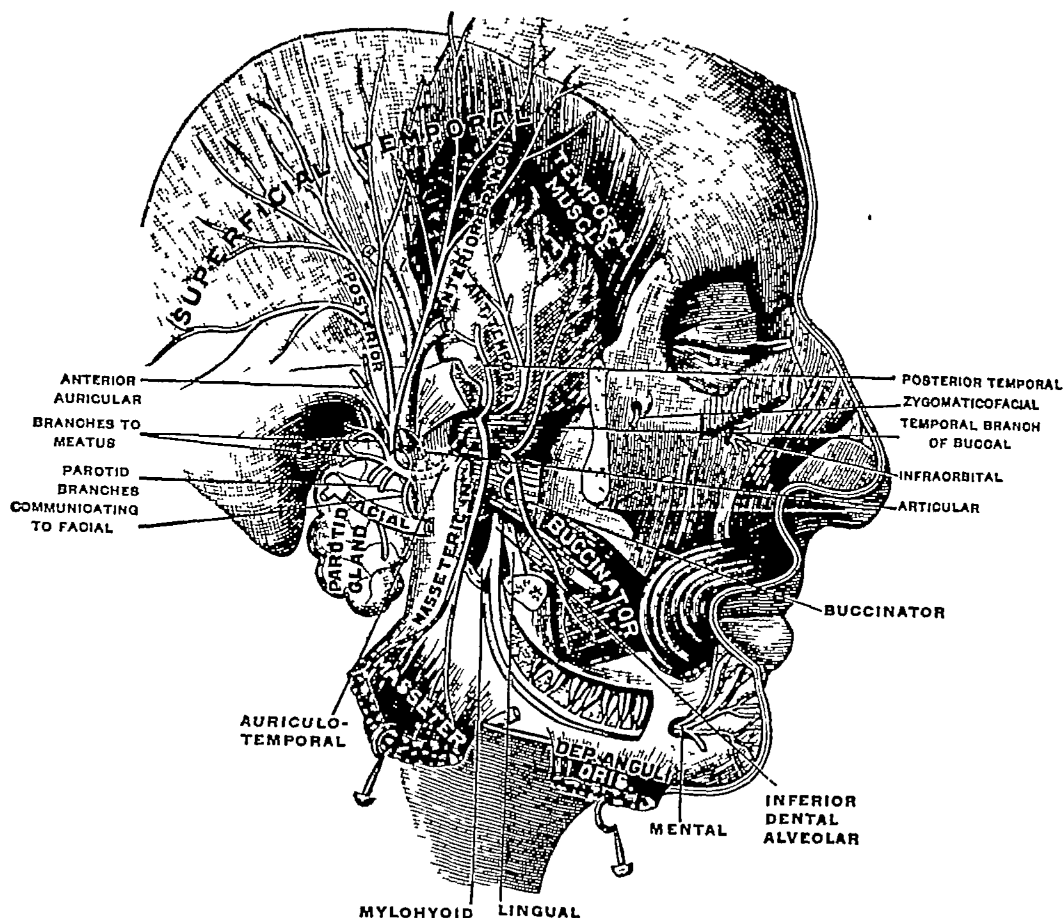


FIG 16 —Mandibular division of trigeminal nerve (Modified from Testut)

Having entered the mandibular foramen the main trunk of the nerve traverses the canal in company with the artery and supplies filaments to the teeth and the adjacent portion of the gum, as far as the mental foramen At this point the nerve divides, the incisive branch continuing forward in the body of the mandible to supply the canine and incisor teeth, and the mental branch, emerging from the foramen to supply the skin of the chin and mucous membrane of the lower lip

The buccal nerve, the only sensory branch of the anterior or motor division of the fifth nerve, joins with the buccal branch of the seventh or facial nerve to form a plexus around the facial vein, and also sends branches to supply the mucous membrane of the cheek as far forward as the angle of the mouth and the skin of the cheek

The Mandibular Joint —The mandibular joint (Figs 18, 19 and 20) is a compound joint, the elements of which are the socket, the condyle, and the meniscus, or interarticular disk of fibrocartilage The entire cavity is enclosed by a capsular membrane.

SMALL PETROSAL
OTIC GANGLION
BRANCH TO TENSOR PALATI
NERVE TO INTERNAL PTERYGOID
TENS. PAL.
INF. ALVEOLAR
LINGUAL N.
MYLOHYOID N.
INT. PTERYG.
WHARTON'S DUCT
SUBLINGUAL GL.
SUBMAXIL. GLAND
BRANCH TO TENSOR TYMPANI
BRANCH TO AURICULO TEMPORAL
BRANCH TO TENSOR PALATI
CHORDA TYMPANI
MIDDLE MENINGEAL ART WITH SYMPATHETIC PLEXUS
AURICULO-TEMPORAL
BRANCH FROM GANGLION TO SUBLINGUAL GLAND
TO MYLO HYOID
TO DIGASTRIC
HYPOGLOSSAL
LOOP BETWEEN LINGUAL AND HYPOGLOSSAL
CHORDA TYMPANI
SYMPATHETIC ROOT OF GANGLION
SUBMAXILLARY GANGLION
NERVE TO INTERNAL PTERYGOID
SMALL PETROSAL
BRANCH TO TENSOR TYMPANI
OTIC GANGLION
BRANCH TO CHORDA TYMPANI
NERVE TO TENSOR PALATI

FIG 17 —Mandibular division of trigeminal nerve (Modified from Testut)

The socket includes the mandibular fossa and the articular eminence of the temporal bone The socket is bounded behind by the Glaserian fissure The tympanic plate behind it intervenes between the condyle and the external auditory meatus

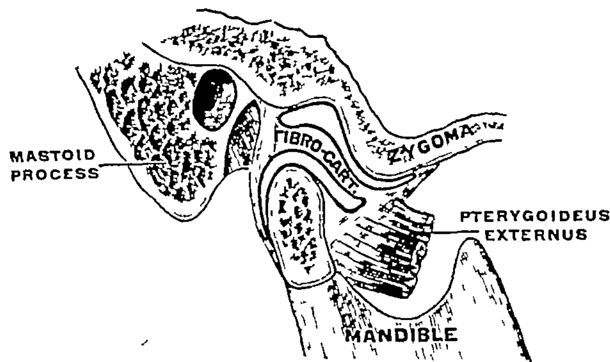


FIG 18 —The mandibular joint, sagittal section (Testut)

The interarticular disk is concave both above and below, and may be 1 mm in thickness in the middle normally or may be perforated in old age or thickened in diseased conditions The thin capsule is attached to

the edges of the disk and the external pterygoid muscle sends fibers of attachment to its anterior border, drawing it forward when the mouth is opened



FIG 19 —Mandibular joint, ligaments, external view (Testut)

The temporomandibular ligament is a strong collection of fibers strengthening the capsule externally The fibers run downward and backward from the zygoma to the outer side of the neck of the condyle

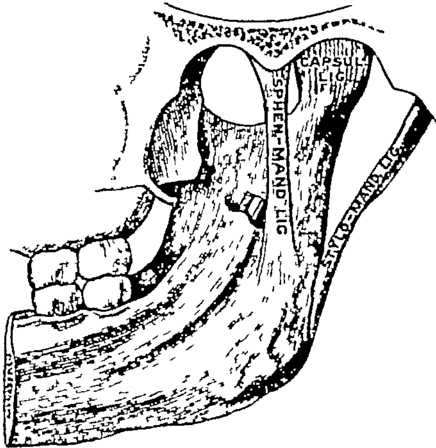


FIG 20 —Mandibular joint, ligaments, mesial view (Testut)

The sphenomandibular ligament is a comparatively weak structure running from the spine of the sphenoid to the lingula of the mandible It has no direct connection with the joint

The stylomandibular ligament runs from the styloid process to the angle of the mandible These ligaments act as suspensories of the lower

jaw "The movements permitted by the mandibular articulation are more varied and of a greater number than those of any other joint in the body The jaw has the power of extension and retraction, one or both sides, it can be depressed and elevated, moved from side to side, and combines all the movements intermediate between these, thus allowing the gliding motion necessary to mastication." (Cryer)

RELATIONS OF THE TEETH

In the reduction and fixation of the fragments in fractures of the upper jaw, or of the lower jaw, or of both jaws coincidentally, we are guided principally, when they are present, by the relationship of the mandibular to the maxillary teeth and of the denture as a whole to the oral cavity

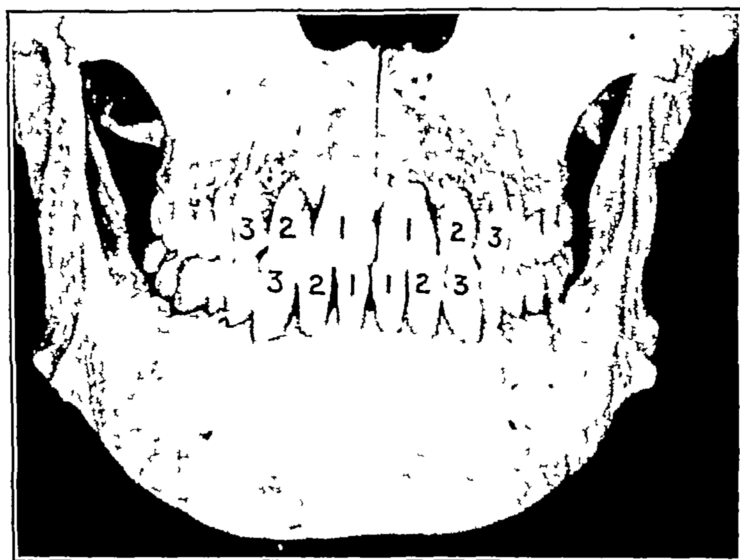


Fig 21 —Articulation of teeth, anterior view (Cryer) 1, first incisors, 2, second incisors, 3, canines.

While it is uncommon to find a set of perfect teeth in cases of fracture, it is nevertheless essential that the surgeon or dentist who is to treat such cases have a knowledge of the correct relationship of the teeth.

Each adult jaw should contain 16 teeth, 2 incisors, 1 canine, 2 premolars and 3 molars on each side (Figs 21 and 22) The teeth are all in contact with their neighbors in the human mouth, and when the jaws are closed there is contact between the opposing maxillary and mandibular teeth

The maxillary teeth are arranged in the form of a semi-ellipse with the long axis passing between the first incisors The mandibular teeth are similarly arranged, but on a slightly smaller curve so that in occlusion the maxillary teeth project a little labially and bucally in relation to the mandibular teeth at all points of the arch The canines are slightly prominent, giving a fulness to the angles of the mouth In the maxilla there is a forward inclination of the incisors, which overlap those of the mandible so that, with the mouth closed, the cutting edges of the latter make contact

with the lingual surfaces of the former from one-fourth to one-third of the distance from the cutting egde to the gingival border

In describing the relationship of the teeth to one another, we quote from G V Black[1]

"At their cutting edges the maxillary first incisors are about one-third wider mesio-distally than the mandibular first incisors The maxillary first incisor, therefore, occludes with the mandibular first, and also with one-third to one-half of the mandibular second incisor The maxillary second incisor occludes with the remaining portion of the mandibular second incisor and the medial portion of the mandibular canine The

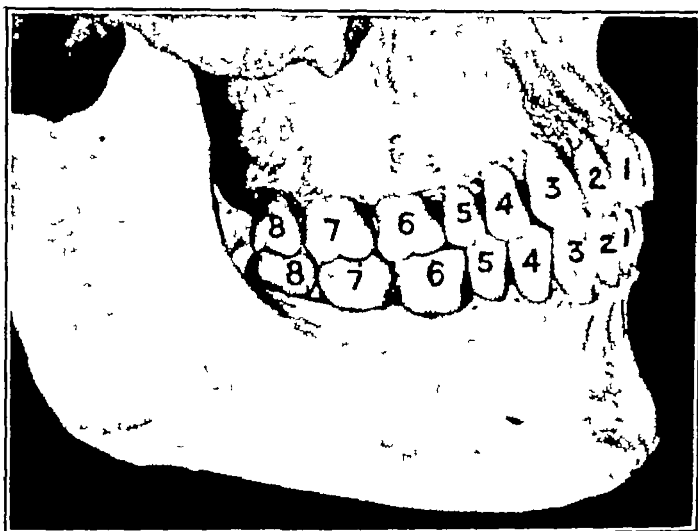


FIG 22 —Articulation of teeth, side view (Cryer) 1, first incisors, 2, second incisors, 3, canines, 4, first premolars, 5, second premolars, 6, first molars, 7, second molars, 8, third molars

maxillary canine is usually rather broader mesio-distally than the mandibular, and in occlusion covers its distal two-thirds and about one-half of the mandibular first premolar, so that its lingual, or triangular ridge, is between the cusp of the mandibular canine and the buccal cusp of the mandibular first premolar, the point of its cusp overlapping the mandibular teeth The buccal cusp of the mandibular first premolar occludes in the space between the maxillary canine and the maxillary first premolar This order is now maintained between the premolars The buccal cusp of the maxillary first premolar overlaps (to the buccal) the space between the two mandibular premolars, and its lingual cusp occludes in the sulcus between them, while the buccal cusp of the mandibular second premolar occludes in the sulcus between the two maxillary premolars The cusps of the maxillary second premolar occlude between the mandibular second premolar and first molar The broad surfaces of the molars come together so that the mesial two-thirds of the maxillary first molar covers the distal two-thirds of the mandibular first molar, and the distal third of the maxillary first molar covers the mesial third of the mandibular second molar. This brings the oblique ridge of the maxillary molar between these two mandibular teeth

This order is continued between the remaining molars, but less perfectly as the teeth are more irregularly formed The maxillary third molar is usually smaller than the mandibular third molar, yet it generally extends over its distal surface "

(In the above quotation we have used certain words displacing those of the author, *viz* first and second for central and lateral incisors, canine for cuspid, premolar for bicuspid, maxillary and mandibular for upper and lower)

The line of occlusion from before backward does not represent a plane but rather falls on the arc of a circle, which touches the front of the condyle behind and the cutting edges of the mandibular incisor teeth in front and centers on the crest of the lacrymal bone.

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CHAPTER II

GENERAL CONSIDERATIONS ON FRACTURES

BEFORE entering upon details of fractures of the jaw bones, there are certain features common to all fractures which should be considered briefly

A **Etiology.**—The causes of fracture are *predisposing* and *exciting* Predisposing causes are

1. Certain *general bone diseases* which cause either softening or brittleness of the bones Among these may be mentioned rickets, osteomalacia, and fragilitas ossium.

2 *Local bone disease*, such as tumors (carcinoma, sarcoma), cysts and osteomyelitis In cases such as these the amount of trauma necessary to produce fracture may be very slight Fracture of a diseased portion of bone is usually called a *pathological* fracture

The *exciting* cause of fracture is trauma or violence Trauma may be (*a*) direct, when the fracture occurs at the point of application of the trauma, or (*b*) indirect, when the fracture occurs at a point in the bone distant from the injury (*c*) Fracture may also be due to sudden *muscular contraction*

B **Varieties of Fracture** —There are several ways of classifying fractures The following are the forms usually mentioned

1 A *greenstick* fracture is an incomplete fracture, occurring in the soft bones of young children, in which some of the incompletely calcified fibers bend instead of breaking, like a green stick of wood

2 A *simple* or *closed* fracture is one in which there is no wound of communication between the site of bone injury and the external air

3 A *compound* or *open* fracture is one in which the fracture communicates with the external air through the wound The main reason for distinguishing between closed and open fractures is that the latter are more susceptible to infection from without Most fractures of the body of the mandible are open to infection through a tear in the oral mucous membrane Most fractures of the ascending ramus of the mandible are closed, that portion of the bone being protected by thick muscles.

4 A *comminuted* fracture is one in which the bone is shattered into several small fragments

5 An *impacted* fracture is one in which one fragment is driven into another and remains fixed there This frequently happens in the case of the malar bone

6 A *depressed* fracture is one in which a flat portion of bone is driven in on the underlying tissues This may be seen occasionally in the facial surface of the maxilla, the fragment being driven into the maxillary sinus It also frequently occurs in the malar bone

C **Symptoms and Signs of Fracture** —1 *Pain* —Pain is usually acute, and aggravated by the slightest movement of the injured part Pain is felt at the site of the fracture on movement of another part of the bone.

2 *Tenderness* on pressure at the point of injury to the bone

3 *Disability*, or interference with function, is an obvious result of fracture, and varies according to the bone involved

4 *Swelling* is usually present at the site of fracture, due to effusion of blood and serum into the surrounding soft tissues

5 *Discoloration* of the skin or mucous membrane, as the effused blood reaches the surface

6 *Deformity* in shape of the bone is usually present, and is due in part to the direction and strength of the force producing the fracture, to the direction of the line of fracture, and to the contraction of muscles attached to the fragments Gravity may also play a part in the deformity In the lower jaw muscular pull is the most important factor in deformity, in the upper jaw, the direction of the fracturing force and gravity are more important

7 *Abnormal mobility* at the site of fracture, where rigidity should be found, is one of the pathognomonic signs.

8 *Crepitus*, or a grating feeling transmitted to the examining hand when the parts are manipulated is caused by the fractured surfaces rubbing against one another Painful manipulation to obtain crepitus should be avoided where possible, as the diagnosis of fracture can usually be made by other means

These clinical signs should always be confirmed by Roentgen-ray examination

CHAPTER III

FRACTURES OF THE MANDIBLE

THE lower jaw is more exposed to violence and consequently is more often fractured than any other facial bones.

ETIOLOGY OF FRACTURES OF THE MANDIBLE

Trauma of some kind is responsible for most fractures of the mandible. Pathological fractures are seen occasionally, complicating tumors, cysts, or osteomyelitis About 90 per cent of the cases occur in males In 100 consecutive cases studied by us,[11] the bare fist was responsible for 49 Fourteen were occasioned by falls, which ranged from an 80-foot drop from a scaffolding and a plunge of 9 floors in an automobile down an elevator shaft to a short fall caused by a banana peel Eight per cent of the cases were complications of automobile accidents, although we believe that a compilation of more recent cases would give a much higher percentage from this cause Five per cent of the cases were connected with the extraction of teeth, principally impacted third molars Three per cent were acquired playing football (Table 1)

TABLE 1

Cause	Per cent
Bare fist	49
Falls	14
Automobile accidents	8
Extraction of teeth	5
Football	3
Miscellaneous	21

A rough compilation of our fracture cases during the past ten years shows the automobile to be responsible for at least 25 per cent of mandibular fractures

LOCATION OF FRACTURES OF THE MANDIBLE

The mandible may be fractured at any point Imbert and Real[3] classify these fractures as (*a*) partial, in which a border of the bone is broken off, without solution of continuity of the bone as a whole, and (*b*) complete, in which there is a loss of continuity of the bone as a whole

Partial Fractures.—Under partial fractures are noted: (1) Fracture of the teeth, which may occur alone, or accompany complete fractures or fractures of the alveolar process. (2) Fracture of the alveolar process, which may also be a complication of a complete fracture or exist alone (3) Fractures of the inferior border of the mandible, which usually unite without difficulty Occasionally, when complicating complete fractures, the fragments are thrown off as sequestra. (4) Fracture of the coronoid process, which is occasionally seen as a result of direct violence; and is often very difficult to demonstrate clinically or radiographically. (5) Perforation

fractures are sometimes seen as the result of a projectile traversing the bone without interrupting its continuity

Complete Fractures.—Complete fractures may be situated at any point along the bone from the symphysis to the condyle There may be a single fracture or two or more fractures Comminution may or may not be present In a recent series 68 per cent of the fractures were single, 31 per cent were double, and there was one triple fracture of the symphysis and necks of both condyles

Of the 68 single fractures the locations were Angle 30, or 44 1 per cent, mental foramen region 21, or 30 8 per cent, symphysis, 6, or 8 8 per cent, molar region 6, or 8 8 per cent, neck of condyle 5, or 7 3 per cent

TABLE 2

	Cases
Single	68
Double	31
Triple	1
Of 68 single fractures	
Angle	30, or 44 1 per cent
Mental foramen	21, or 30 8 "
Symphysis	6, or 8 8 "
Molar region	6, or 8 8 "
Neck of condyle	5, or 7 3 "
Of 31 double fractures	
Mental foramen one side and angle opposite side	24, or 77 4 per cent
Mental foramen region and angle same side	2, or 6 4 "
Angle and symphysis	2, or 6 4 "
Condyle and mental foramen same side	1, or 3 2 "
Condyle and angle opposite side	1, or 3 2 "
Both mental foramina	1, or 3 2 "

The double fractures were located as follows Mental foramen region of one side and at or near the angle on the opposite side 24, or 77 4 per cent, mental foramen region and angle of the same side 2, or 6 4 per cent, angle and symphysis 2, or 6 4 per cent, and 1 each, or 3 2 per cent, at condyle and mental foramen of the same side, condyle and angle of the opposite side, and both mental foramina

In 1936 over 36,000 persons were killed and nearly a million injured by automobiles Many of those injured were thrown forward against the dash with such force that all the bones of the face were broken Accordingly, of late years, we are seeing an increasing number of cases with fractures of one condyle, both condyles or a combination of symphysis, usually with comminution, and one or both condyles

Hence, the percentage location of fractures as shown in Table 2 has changed, with a marked increase in those at the symphysis and condyles, with a consequent decrease in other locations

It will be observed that in the majority of bilateral cases, the fracture on one side is in the mental foramen region and at or near the angle on the other A blow delivered on the body of the jaw on one side is very likely to fracture the angle of the same side and the mental foramen region on the other Thus, fracture by indirect violence is frequent *In every case of fracture in the region of the mental foramen, we should always look for a*

second fracture at the angle on the opposite side, it will be found in about 55 per cent of the cases It is surprising how many times a roentgenogram is made of but one side where the fracture is apparent, a fracture of the opposite side being overlooked

SYMPTOMS AND DIAGNOSIS OF FRACTURES OF THE MANDIBLE

The following diagnostic features are important in fractures of the mandible

1 **History of Injury.**—History of injury is invariably present unless we are dealing with a pathological fracture

2 **Deformity.**—In the majority of fractures of the mandible the diagnosis can be made by inspection alone, which will reveal more or less marked deformity either with the jaw at rest or on requesting the patient to open the mouth In the body of the bone, where a majority of teeth

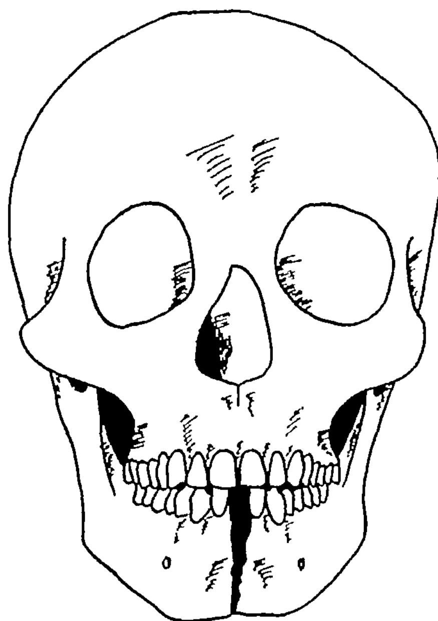


FIG 23 —Fracture through symphysis of mandible, showing separation above, due to contraction of mylohyoid muscles attached to lower borders

are present, there will usually be an alteration in the alignment of the teeth, so that occlusion with the maxillary teeth will be disturbed In some cases this disturbance may be so slight as to be overlooked by one unfamiliar with normal occlusion of the teeth Where many teeth are absent also, it may be difficult by inspection alone to detect a change in position of part of the mandible The degree of displacement in fracture of the mandible depends on the direction and strength of the traumatizing force, the direction of the line of fracture, the amount of comminution, the presence or absence of teeth, and above all, the action of the muscles attached to the separated fragments Fractures in different locations present definite characteristic displacements

Fracture of the Symphysis.—This may be vertical directly at the median line between the two first incisor teeth (Fig 209) or may be between the first and second incisors (Fig 210), or between the second incisor and canine (Fig 211) The line of fracture may also be more or less oblique (Fig 212) or angular In slight injuries in this region, the bilateral muscular forces are working symmetrically, consequently displacement may be hardly noticeable, unless it be a tendency to separation at the upper end of the fracture line due to contraction of the mylohoid muscles attached along the lower borders (Fig 23) One side may be depressed slightly below the other Where there is considerable comminution or loss of substance of the symphysis, with loss of teeth, the two halves of the mandible tend to be drawn together at the median line by contraction of the mylohyoid muscles, so that there is a marked narrowing of the lower dental arch (Fig 24) This is one of the most difficult deformities to overcome, and the fragments must be maintained in position longer than usual if a contracted lower dental arch is to be avoided

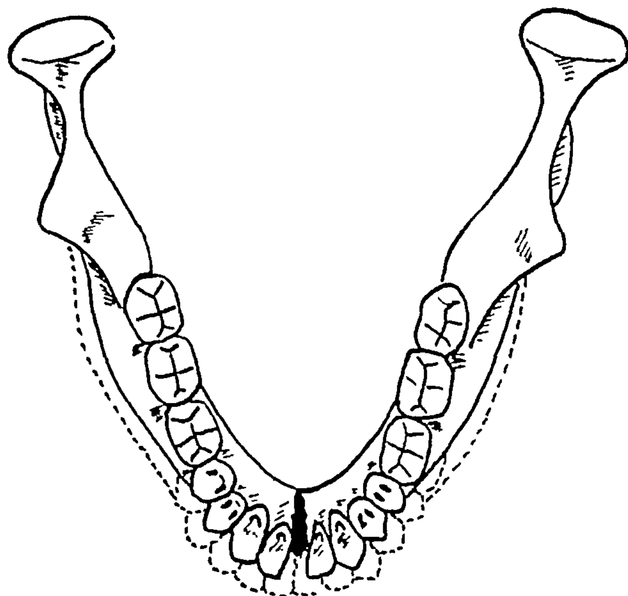


FIG 24 —Marked narrowing of mandibular dental arch in cases of fracture at symphysis with loss of bone and incisor teeth

Mental Foramen Region.—With a good complement of teeth in both upper and lower jaws, the short fragment is elevated and held with the teeth in normal occlusion with those of the upper jaw by contraction of the elevator muscles (temporal masseter and internal pterygoid) The large fragment is depressed by the muscles running from its lower border to the hyoid bone, so that the anterior teeth do not occlude with those of the upper jaw (Fig 25) In severe cases there may also be some backward displacement and a lateral deviation of the chin to the side of the fracture, with overlapping of the fragments The line of fracture is usually slightly oblique forward and upward Where teeth are missing from the short fragment, and the usual obliquity of the fracture line exists, the elevator muscles accentuate the displacement because there are no opponents for

the posterior teeth of the upper jaw Where the obliquity of the fracture line is in the other direction, *i e*, backward and upward, a rare occurrence, the displacement may be very slight

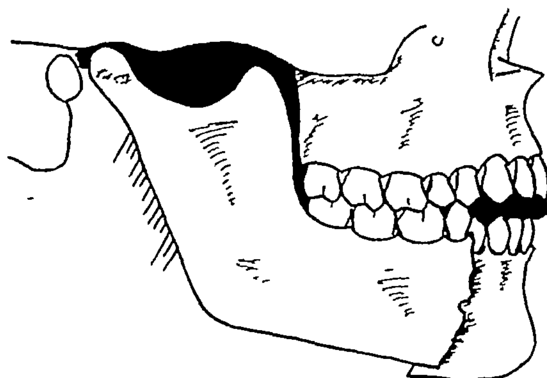


FIG 25 —Fracture in mental foramen region, showing elevation of fragment posterior to fracture and depression of fragment anterior to it

Fracture in the Molar Region.—Here the displacement is similar to that in the mental foramen region, *viz*, the short fragment held up by the elevator muscles and the large fragment drawn down in front by the depressors The short fragment also is frequently drawn in toward the median line, its anterior end being overlapped by the long fragment The obliquity and direction of the fracture line here also has considerable influence on the amount of displacement, as has also presence or absence of opposition by the maxillary teeth (Fig 26)

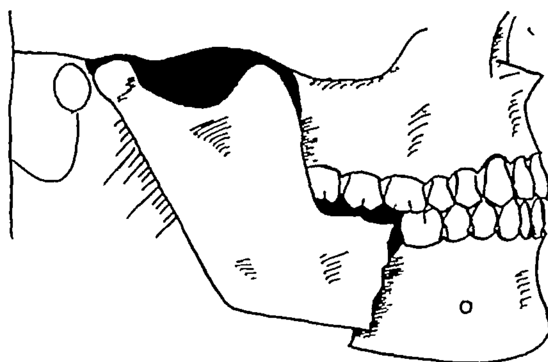


FIG 26 —Fracture in molar region, showing elevation of long edentulous posterior fragment

Fracture Through the Angle.—The lower end of the short fragment is generally displaced upward and forward by contraction of the elevator muscles In addition, slight inward displacement is more common than external The larger fragment is frequently drawn slightly toward the fractured side

Fracture of the Ascending Ramus—Fracture of the ascending ramus may be oblique, horizontal, or vertical from the mandibular notch downward Displacement is usually slight, owing to investiture of the fragments by thick muscles When present, it is manifested by a deviation of the chin toward the fractured side.

Fracture Through the Neck of the Condyle.—Fracture through the neck of the condyle has been dealt with in great detail in the excellent work of Doufourmentel[8] This fracture is nearly always indirect, and is usually occasioned by a fall or blow on the opposite side of the chin It is some-

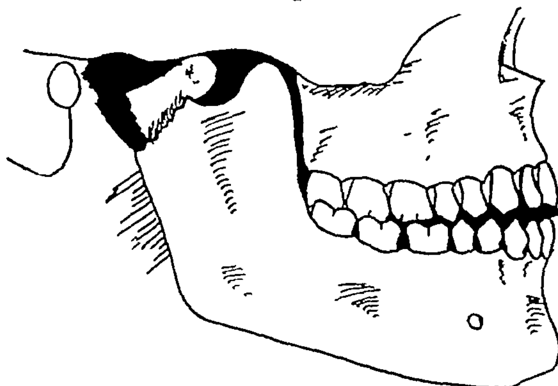


Fig 27 —Fracture through neck of condyle with forward dislocation of condyle

times accompanied by a fracture in the region of the symphysis Sometimes, depending on the direction of the fracture line, the condyle is pulled forward and inward out of the mandibular fossa by the external pterygoid muscle (Figs 27 and 28) Where the fracture line runs obliquely backward and outward from above, the condyle may remain in its socket, with



Fig 28 —Roentgenogram showing fracture through neck of condyle with slight forward displacement of condyle

comparatively little displacement (Figs 29 and 30) In any case, there is a shortening of the distance from the angle of the mandible to the mandibular fossa on that side, so that when the patient tries to open the mouth the distance between maxillary and mandibular molar teeth on that side is less than on the normal side, and the main part of the lower jaw drifts toward the injured side, so that the central point between the incisor teeth of the upper and lower jaws do not correspond (Fig 31)

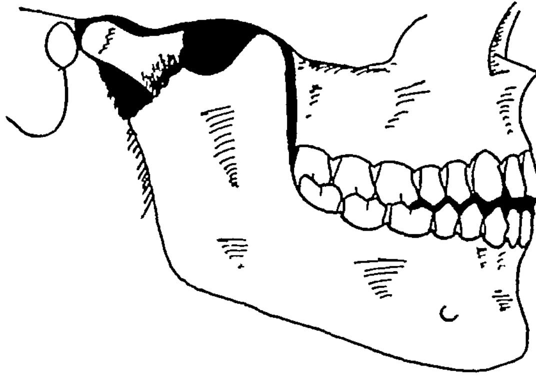


Fig 29 —Fracture through neck of condyle, the head remaining in glenoid fossa



Fig 30 —Roentgenogram showing oblique fracture through neck of condyle

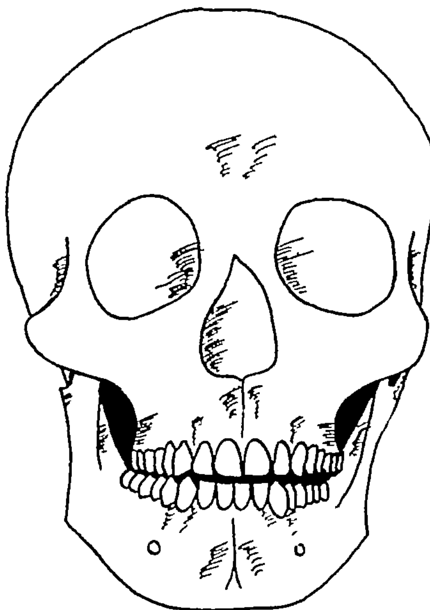


Fig 31 —Fracture through neck of right condyle Shortening of right side of mandible with deviation of teeth to right

Fracture of the Coronoid Process.—Fracture of the coronoid process is nearly always due to a blow on the side of the face The small portion of bine may be drawn upward by the temporal muscle (Fig 32) There is usually no visible deformity beyond external swelling and limitation of opening of the mouth, unless other fractures are present



Fig 32 —Roentgenogram showing fracture of coronoid process

Double Fractures.—In double fractures, the commonest being through the mental foramen region on one side and the angle on the other, the middle segment is drawn down and back by the hyoid group of muscles, the posterior fragments being held up by the elevators (Fig 33) This backward displacement of the middle fragment may be so marked as to interfere with respiration and swallowing

3 **Abnormal Mobility.**—This is readily detected in most fractures of the body of the bone by instructing the patient to move the jaw, when the teeth in two fragments will be seen to move independently In other cases, especially those with slight displacement or behind the line of the teeth, such as at the angle or in the ascending ramus, manipulation may be necessary to bring out this sign In suspected fracture at the angle, for example, the ascending ramus is grasped with the thumb in the mouth and the fingers of the same hand behind the angle With the other hand pressure is made on the chin One should make certain that the abnormal movement is not confined to loose teeth and alveolar process alone, but that it involves the full thickness of the bone

4 **Pain** —Pain is usually severe at first, and aggravated by attempts at movement Manipulation will localize the pain to the seat of fracture.

5 **Tenderness.**—Undue tenderness on palpation at certain points in the absence of other signs may be valuable in locating a fracture

6 **Crepitus.**—Crepitus is pathognomonic of fracture, but it is rarely necessary to subject the patient to the painful manipulation required to bring out this sign, as the diagnosis can generally be made by other means

7 **Laceration** —Laceration of the gum tissue is often noted at the site of a fracture Most fractures of the body of the mandible are compound into the mouth, with a wound of the gum tissue

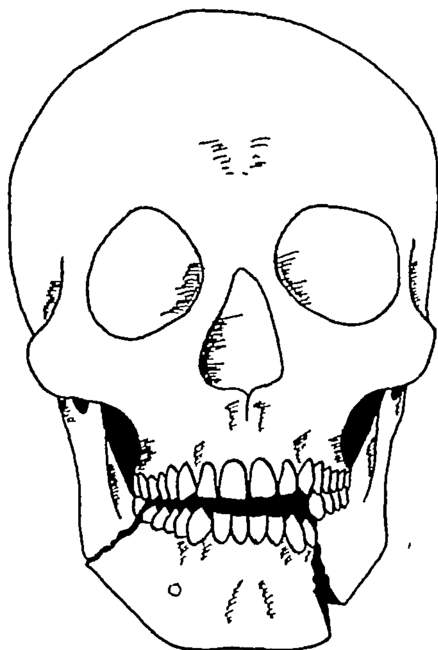


FIG 33 —Double fracture, through mental foramen on left side and angle on right side Downward displacement of middle segment

8 **Discoloration** —Discoloration of the gum tissue or of the skin may be present from effusion of blood into the tissues in the region of the fracture

9 **Swelling.**—Swelling, more or less marked, is usually observed in the soft tissues surrounding the fracture

10 **Disability.**—Disability manifested by a crippling of the movement of the mandible and consequent absence of normal masticating power is always more or less evident Trismus, or limitation in opening the mouth is a constant sign in fractures near the angle of the mandible

11 **Salivation.**—Salivation and *fetor of the breath* are the results of absence of normal movements of the jaw, stagnation of food, infection, etc

12 **Numbness.**—Numbness of the side of the lower lip and gums in the anterior region of the mandible may be observed, due to severing of the inferior dental nerve at the site of fracture

13 **Roentgen-ray Examination.**—Roentgen-ray examination is of prime importance in connection with fractures of the mandible as with fractures elsewhere The diagnosis can usually be made by other signs, but the roentgen-ray is valuable in giving the exact location, the direction of the line of fracture, amount of comminution, relation of tooth roots, and as a

permanent record, especially in case of medico-legal complications Roentgen-ray examination is also useful during the course of treatment as a check-up on the presence of sequestra, callus formation, dental infection, etc We place little reliance on roentgenological reports as to position of fragments or as a check-up on position after reduction For example, the roentgen-ray report might say that there was a fracture of the body of the mandible, with fragments in good position, and the surgeon if he relied on this report solely would be tempted to let the case alone, whereas in spite of such a report clinical examination might show a marked disturbance of the occlusion of the teeth Here, the clinical findings are far more important than the roentgen-ray report On the other hand, after reduction and fixation of a fracture in the region of the angle of the mandible, with the teeth in good occlusion, the roentgen-ray report might say that the posterior fragment was still out of line, but this would be no indication for attempting further reduction, because union in this position would give a perfectly satisfactory functional result The technique for roentgenological examination in suspected fractures of the jaw bones is given by Dr L M Ennis in Chapter VII

TREATMENT OF FRACTURES OF THE MANDIBLE

The treatment of fracture of the mandible, as in fracture of any other bone, consists in reduction of the fragments to as nearly normal position as possible and fixation until union occurs In the mandible, when teeth are present, more accurate restoration of the parts is essential than in other bones, because the slightest deviation will produce malocclusion of the teeth and interfere with mastication The essential principle to be followed, therefore, is fixation of the fragments in proper relation with the upper jaw In order to minimize infection and the prolonged treatment resulting therefrom, this fixation should be applied as soon as possible

Preliminary Measures —Before reduction and fixation, certain preliminary measures should be carried out Teeth whose roots are exposed in the line of fracture or which have been markedly loosened, should generally be removed, provided that this can be done without too much traumatism to the fracture, because such teeth usually give rise to infection sooner or later However, in certain cases it may be advisable to retain such a tooth for a time, even at the risk of infection This applies particularly to a fracture just in front of the last molar tooth, where loss of the tooth would mean upward displacement of the posterior fragment owing to lack of opposition from the maxillary molars (Fig 34) After a week or ten days of reduction, the posterior fragment will usually remain down in position, and the tooth in line of fracture can then be removed In comminuted fractures conservatism should be practised with regard to loose bone fragments Only those which have become completely detached from the soft tissues should be removed at this time But bone fragments having any attachment to the soft tissues should be allowed to remain, as they frequently keep their vitality and aid in restoring continuity of bone

It is much wiser to leave a bone fragment of doubtful vitality, removing it later in case of necrosis, than to perform a radical débridement of all loose fragments, with a resultant bone defect requiring grafting later In fractures complicated by extensive wounds of the soft tissues, the fracture should be reduced and fixed before closure of the soft tissue wound, because if the fragments are allowed to become fixed in malposition by scar formation in the soft tissue, reduction later may require extensive operations, entailing great loss of time



FIG 34 —Roentgenogram showing fracture just anterior to last molar tooth, temporary retention of which is important in maintaining posterior fragment in position

Keeping the Mouth Clean.—Before application of the fixation, all diseased and useless tooth roots, tartar, etc , should be removed During the course of treatment, attention should be given to oral hygiene The patient should be encouraged to keep the teeth and mouth clean, with a brush, if possible, if not, by the use of a mouth wash, particularly after feeding A softened tooth brush may be used on the labial and buccal surfaces of the teeth after fixation, with care not to entangle the bristles in the wires, but this is quite obviously impossible on the lingual surfaces This area may be kept fairly clean by the addition of 2 teaspoonsful of hydrogen peroxide to any of the ordinary mouth washes—an excellent wash for any intra-oral condition—and gentle massage with the tongue Every two or three days the gums and teeth should be swabbed with hydrogen dioxide, followed by application of Talbot's iodine solution around the necks of the teeth after drying Talbot's solution consists of the following

Zinc iodide	15 parts
Distilled water	10 "
Iodine	25 "
Glycerin	50 "

Methods of Fixation —The means suggested for bringing about reduction and fixation have been many Several of these will be mentioned, but not recommended

Head Bandage —A method popular with some surgeons is the application of the Barton or other head bandage, either alone or in combination with some form of pasteboard or metal cup to fit the chin The bandage is no more reliable here for retention after reduction of displaced fragments than it would be in a fracture, for example, of both bones of the forearm No head bandage can be applied sufficiently tight to fix fragments which show a tendency to displacement, without strangling the patient, even when combined with a moulded chin cup Moreover, the turn of the Barton bandage running around the front of the chin tends to pull the chin backward, thus actually increasing the displacement in certain types of fracture Only cases which would do well without any form of fixation whatever show satisfactory results after treatment with the bandage If



FIG 35 —Figure-of-eight head bandage

the fragments are properly fixed otherwise, no bandage is necessary, except to hold a dressing in case of external wound The bandage when employed should be a modification of the Barton, in which the turns pass *beneath* the chin, instead of in front of it (Fig 35)

Combined Oral and Extra-oral Splints —Some text-books describe certain splints consisting of a metal tray fitting over the mandibular teeth connected by a bar to a metal or vulcanite cup beneath the chin It is impossible with splints of this type to maintain the fragments in correct position and, moreover, we have seen extensive devitalization of the soft tissues from pressure occasioned by their use This splint also seriously interferes with access to the tissues in case of drainage at the lower border of the mandible

Direct Fixation of Fragments by Wiring or Plating the Bone —Sometimes, in a case of difficult reduction, the surgeon may be tempted to wire or plate the fragments, forgetting or ignoring the fact that nearly all mandibular fractures are compound into the mouth and are constantly bathed

in the oral secretions Infection occurs around the wire or the metal plate, inviting osteomyelitis with sequestrum formation and great delay in union The only justification for wiring or plating of the fragments is one of those rare cases of fracture in an edentulous person where the oral mucous membrane has not been broken and where there is consequently a chance of maintaining asepsis Even here, the wire or plate usually gives insufficient stability

Methods Utilizing the Teeth as Points of Fixation —The principal aim in view in treating a fracture of the mandible is restoration of the normal occlusion of the teeth of the lower jaw with those of the upper jaw Therefore the most satisfactory methods of treatment are those which maintain this relationship by appliances attached to the teeth, thus indirectly fixing the bone fragments These appliances fall into two categories, (1) interdental splints and (2) wire ligatures and arches

1 *Interdental Splints* —In the average text-book on surgery, under fractures of the mandible, various types of more or less complicated splints are shown, without specific instructions as to their use, except that they can be made by a dentist But definite practical information as to how to reduce and fix the fragments quickly and efficiently is usually lacking An interdental splint is a piece constructed of metal, vulcanite, celluloid or plastic material, made to fit accurately over the teeth of the individual case, holding the teeth in the positions they occupied before the fracture occurred, so that the bone fragments are thus indirectly held in normal position until union has taken place In some cases the splint covers teeth of the lower jaw only, in others, the upper and lower teeth are fixed in occlusion by a splint or by two splints covering both upper and lower teeth In the construction of these splints, impressions of the mouth must first be made, and great accuracy in technique is necessary so that the finished splint will fit perfectly It is unquestionably true that a properly fitting interdental splint, after it has once been made and applied, is a very efficient form of fixation for fracture of the mandible Unfortunately surgeons are being confronted with an increasing number of these injuries, and those skilled in splint making are seldom immediately available There are many practical difficulties which interfere with the routine employment of the splint, chief of which are the experience, time and expense involved Most cases of fracture of the lower jaw occur in persons in poor circumstances who apply for treatment at free dispensaries or dental colleges, where students have to be depended upon for the making of the appliances A busy dentist, even though experienced in this work, and he seldom is, cannot give up all other patients and devote at least two days to making a splint Dental students have numerous duties, such as attendance at classes to interfere, and moreover are insufficiently experienced to produce accurate splints in the desired length of time Under these circumstances usually two or three weeks elapse between the taking of the impressions and the insertion of the splint, which even then may not fit accurately In the meantime, unless some other means of fixation has been used, the fracture is in process of union in malposition For these reasons, for the

average case of mandibular fracture, we do not now depend on splints, but reserve these for the rare cases where simpler methods are not suitable Since we personally have so little occasion to use interdental splints specially made for individual cases, we believe that a detailed description of these appliances would be out of place in this volume However, to avoid the accusation of ignoring a method of treatment regarded by many as important, we will call attention to certain fundamental principles in splint construction It is first of all necessary to obtain accurate impressions of the teeth of the upper and lower jaws These are usually best made with plaster of Paris Plaster casts are then made from these, and the lower cast will represent the mandibular teeth as they appear after the fracture The cast is now cut through with a saw at the place corresponding to the fracture, and the two sections are arranged so that the

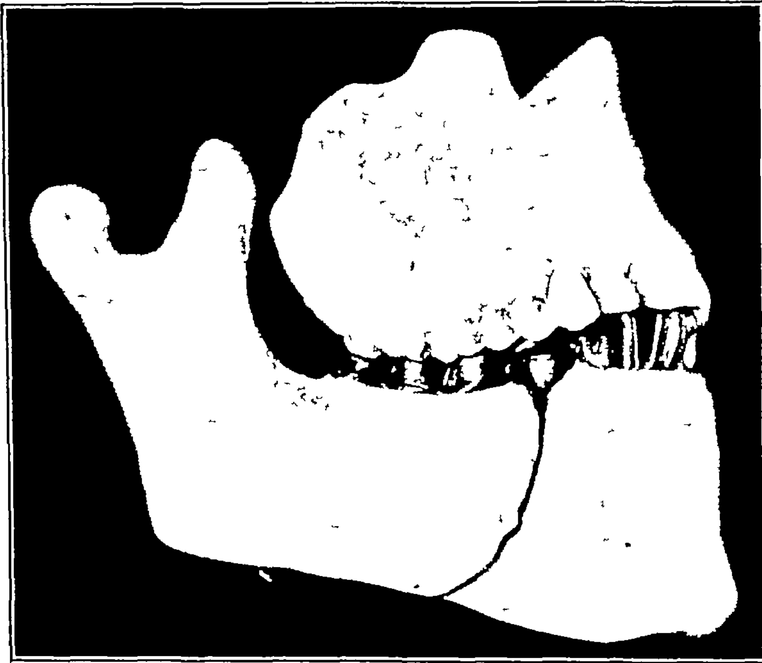


FIG 36 —Cast metal cap splint for mandibular teeth alone (Walter Reed General Hospital)

teeth will occlude correctly with those of the upper cast, i e, will be as they were before the fracture occurred The lower sections of the cast are then fastened together in their reasonable position with plaster From the casts thus obtained various types of splints may be prepared, according to the nature of the case In cases of multiple fracture, or where there is marked displacement, it is frequently advisable to make the impression of the lower teeth in sections, and after pouring the casts from these, assemble the several portions in correct relation with the upper teeth The most modern splints are made of cast coin silver The technique of casting is the same as that used in casting bases for artificial dentures For a fracture with several sound teeth in each segment of the mandible, by far the most comfortable, hygienic and least cumbersome splint is one consisting of a cast metal cap or jacket fitting over several teeth on either side of the fracture (Fig 36) The chief advantage of this device is that

it firmly fixes the fragments and at the same time allows the patient to open and close his mouth If the fracture can be easily reduced, the splint

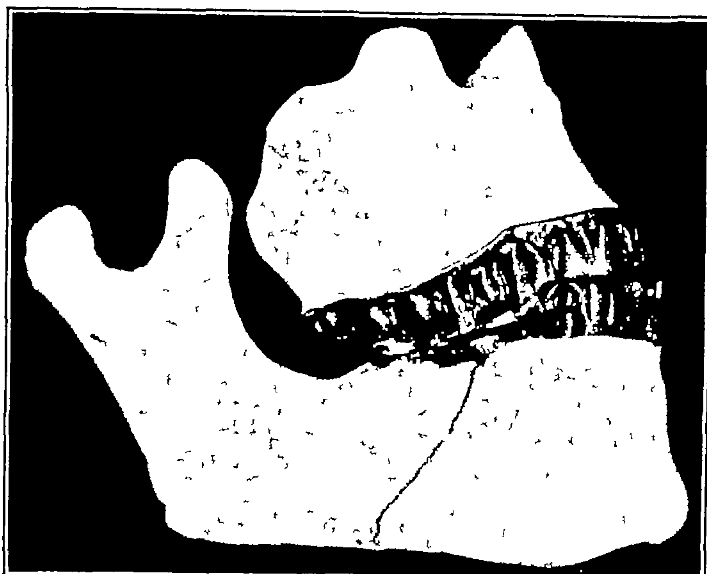


FIG 37 —Cast metal cap splint for both mandibular and maxillary teeth, the upper and lower segments being united by lock-pins (Walter Reed General Hospital)

is immediately cemented in position on the teeth If reduction is not immediately possible, the splint can be inserted over the teeth without cement, and after a few days it will often be found that the teeth have settled themselves into the splint, which can then be firmly cemented

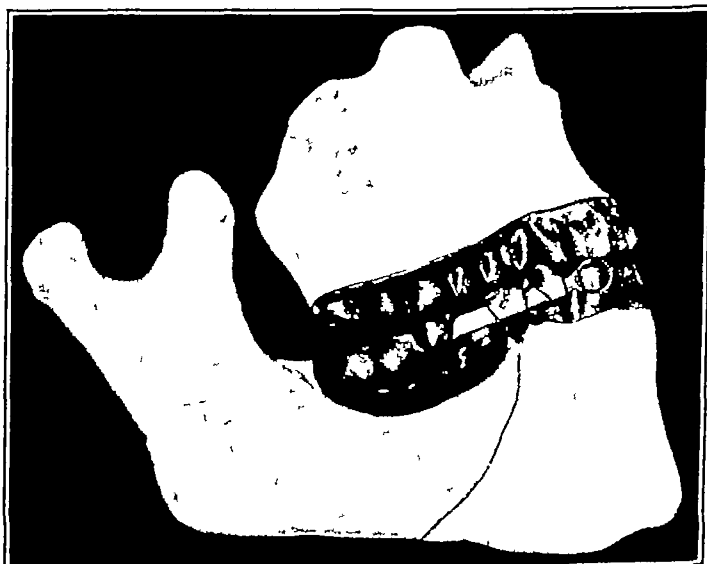


FIG 38 —Cast metal cap splint with vulcanite saddle for long edentulous fragment (Walter Reed General Hospital)

In a fracture with the teeth in only one segment, such as a case involving the angle of the mandible, it becomes necessary to fix the lower teeth firmly to the upper teeth, in proper occlusal relationship This applies also to cases which perhaps have teeth in both segments, but these may

not be sufficient in number or quality to make possible the use of the simple mandibular splint Here, separate cast cap splints are made for the upper and for the lower teeth, provided with hooks or lock-pins, whereby the upper and lower segments can be firmly fixed together

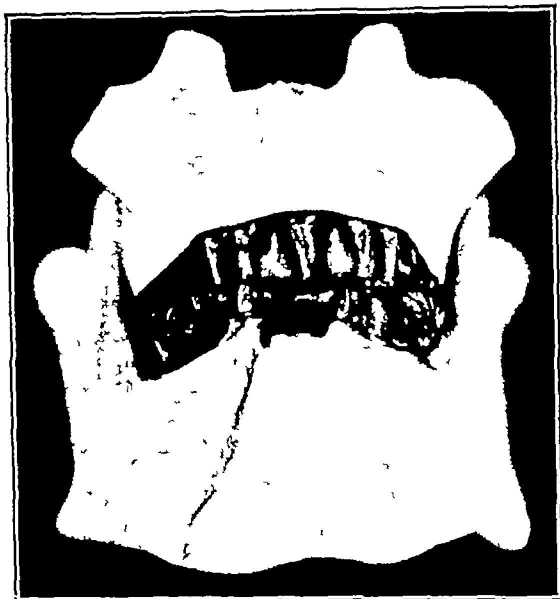


Fig 39 —Cast metal splint, the mandibular portion being made in sections (Walter Reed General Hospital)

(Fig 37) Various modifications become necessary, such as saddles to take care of long edentulous fragments (Fig 38), separate sections with jack-screws, springs, etc, for fragments requiring gradual reduction, and so

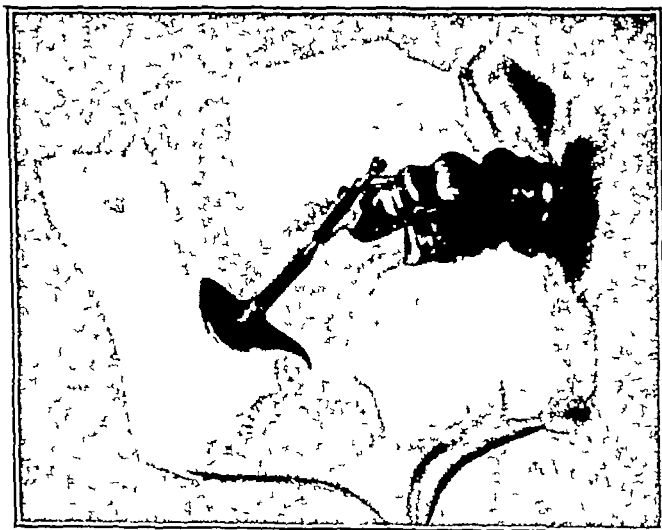


Fig 40 —Cast metal splint with velum rubber extensible saddle for reduction and fixation of ascending ramus (Walter Reed General Hospital)

forth (Figs 39 and 40) Some of these are extremely complicated, and require the services of one with great experience in this special work.

For details of splint construction the reader is referred to the excellent articles of Bodine[4]

Sectional acrylic resin splints have some advantages over the older types, especially those constructed with the clear acrylics, which allow one to observe the condition of the teeth and gingival tissues under the splint at all times (Fig 41)

As in the construction of any type of splint the first requirement for success is perfect impressions and models of the parts to which the finished

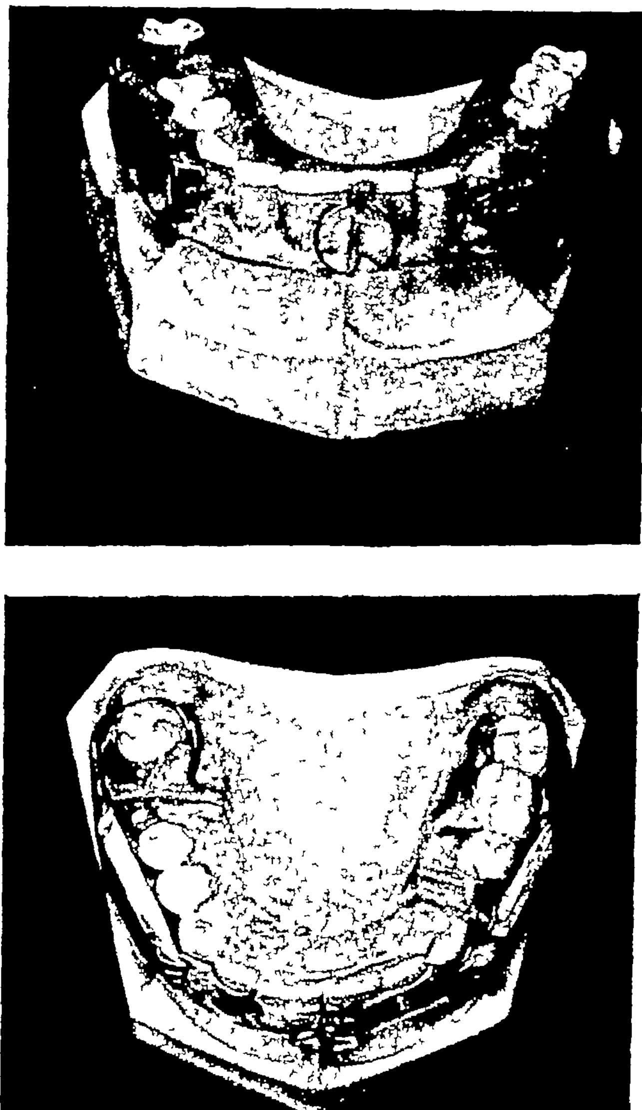


Fig 41 —Clear acrylic splint with parallel square tubes on each side for anchorage of intraoral or extraoral extension arms (Manual of Plastic and Maxillofacial Surgery, W B Saunders Company, p 329)

acrylic splints are to be applied Accuracy is of the utmost importance because, theoretically, no cement is to be used in holding the splints in place, they must, therefore, fit the teeth and gingival tissues perfectly in order to be retained As a matter of fact, we have found, in our limited experience with these splints, that, no matter how perfectly they are made and how closely they fit the teeth and gums, they will not always stay in place when traction is applied It then becomes necessary to

cement them in place The very considerable nuisance of eventually removing a cemented splint is minimized with the use of the sectional splint, but the cement still has to be removed from the teeth—no easy job

The construction of this type of splint is quite complicated, the details of which can be found in the Manual of Standard Practice of Plastic and Maxillofacial Surgery, pages 322–338 (21)

2 *Wire Ligatures and Arches* —The principal advantages of these methods over interdental splints is avoidance of the difficulties and discomfort of impression taking and the delay in preparing the splints from these impressions At the first visit of the patient, in the time ordinarily required to obtain an impression, the case can be permanently fixed with the wires None of the elaborate laboratory apparatus necessary for splint making is required for wiring Other advantages of wiring are that there is no material between the upper and lower teeth, and the teeth are uncovered so that the state of occlusion is under direct observation at all times If, during the course of treatment, it becomes necessary to open the mouth,

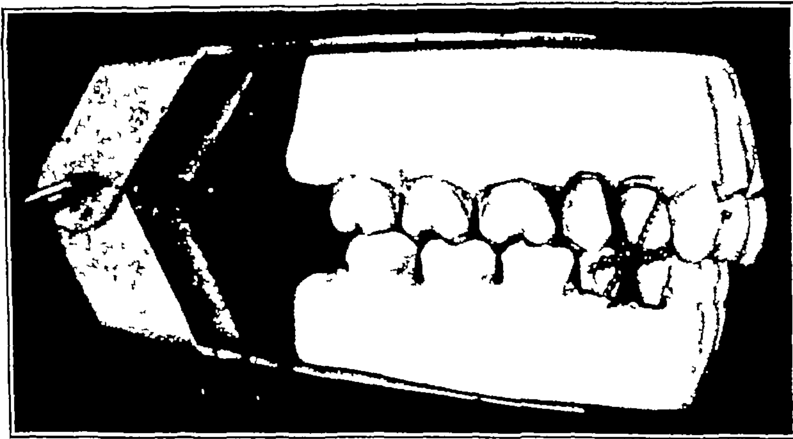


FIG 42 —Gilmer's original method of intermaxillary wiring of the teeth

as for removal of a tooth, it is far easier to cut a few wires and replace them than to remove and replace a splint that is cemented to the teeth, and with less disturbance to the fracture Occasionally, it is impossible to completely reduce the fracture at the first visit, and in these cases the use of wires is invaluable, for they can be readily tightened from day to day as the fragments relax The earliest method of applying wire ligatures to the teeth for fixation of fracture of the mandible is mentioned by Hippocrates This consisted in carrying the ligature *across* the line of fracture from teeth adjacent to it on either side Although this method is sometimes tried even now by the inexperienced, it should not be used, as sufficient stability cannot be obtained and the strain soon loosens the teeth to which the wires are attached Moreover, it is impossible to apply the wires in this way where one of the fragments is without teeth—a very common occurrence

Gilmer[11] some years ago pointed out the value of wiring the lower to the upper teeth in fixation of fractures of the mandible It is upon this principle that the simplified methods now employed are based The

particular method used by us for most cases is by no means original It is a modification of that described by Colonel Robert T Oliver, Dental Corps, U S Army[23] and first called to our attention by Eby[9] in 1918 The technique originally used by Gilmer is still employed by many (Fig 42), although Gilmer himself discarded it several years ago The modification used by us is superior in that it permits more ready access to the mouth for replacement of a broken wire or for other reasons, without disturbing the main attachments on the teeth

Anesthesia —It is preferable, whenever possible, to apply the methods of fixation without general anesthesia, and this can be done in the great majority of cases The objections to these manipulations under general anesthesia are (1) General anesthesia requires the use of a mouth gag to gain access to the inside of the mouth This sometimes causes undue disturbance of fragments, thus increasing the chances of infection (2) The patient during recovery from the anesthetic frequently puts undue strain on the wires and breaks or displaces them (3) Postanesthetic vomiting may give rise to asphyxiation if the maxillary and mandibular teeth are wired together This danger can be avoided in cases where general anesthesia is necessary by applying the eyelet wires or other attachments to the teeth of each jaw during the general anesthesia, postponing the intermaxillary fixation with the tie wires until after the patient recovers consciousness This plan permits free access to the respiratory passages in case of vomiting, and at the same time the most painful part of the procedure has been accomplished In patients who have been properly prepared for the anesthetic, however, we have experienced little difficulty on account of postanesthetic vomiting

It is especially important to leave the jaws separated until after consciousness returns when avertin has been used as an anesthetic, because there is a relaxation of the lower jaw with a tendency for the tongue to fall back into the respiratory passages Some anesthetists routinely use an air way following any operation under avertin, leaving it in position until the return of consciousness At any rate, the tongue must be accessible and controllable in this period of relaxation

Occasionally, it is imperative to resort to general anesthesia, for example, in cases of malunion requiring considerable force in reduction, where teeth and roots in the line of fracture need immediate removal, cases where detached bone fragments must be removed, or where the soft tissues require extensive attention and suturing Here, the usual procedure is to apply the wires or arches to the teeth, but not to fasten the teeth in occlusion until after recovery from the anesthetic

Most of the pain during the process of fixation comes from careless manipulation of the fragments, and not from the placing of the appliances Where desirable, a few drops of local anesthetic solution can be injected into the gum tissue which comes in contact with the wires

Technique of Eyelet Wire Method —*Instruments* —The necessary instruments are to be found in any hospital, and consist of a pair of strong hemostatic forceps, a pair of short-nosed scissors, and a tenaculum or a

Backhaus towel clamp It is also advisable to have a pair of dental dressing pliers

Wire —The wire used should be of such a size that it will pass freely through the spaces at the necks of the teeth, and flexible yet possessed of considerable tensile strength Of all the various kinds of wire we have tried, and there have been many, No 24-gauge soft brass wire has been

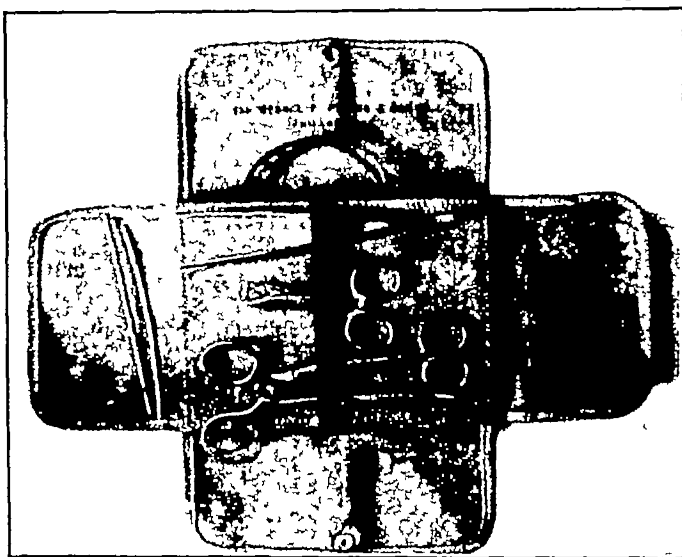


FIG 43 —Author's pocket case, instruments and wires used in fixation of fractures of the mandible

the most satisfactory This is obtainable at any dental supply house or any hardware or five and ten cent store Figure 43 shows a convenient pocket case, containing the instruments and wires required, as well as several lengths of half-round German silver arch wire, required for an alternative method to be described

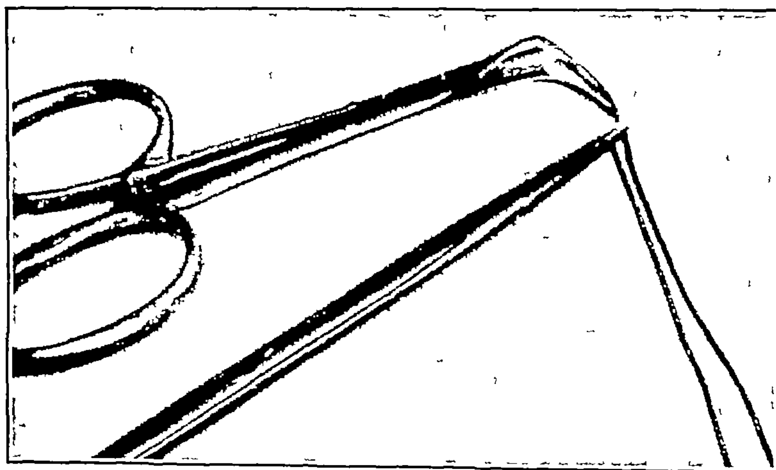


FIG 44 —Making eyelet in 6-inch strand of wire

In preparation of the wire to be attached to the teeth, a 6-inch length is folded at its middle around the tenaculum or towel clamp, and two twists are made with the hemostatic forceps to form an eyelet (Fig 44).

The eyelet should be made as small as possible The teeth usually selected for attaching the wires are the premolars above and below on each side and the incisors in front If the teeth usually selected for wiring are absent, diseased or otherwise unsuitable for attachment, then other teeth are used After selecting the teeth to which attachments are to be made and noting that they have corresponding opponents in the other jaw, both ends of the eyelet wire are inserted from the vestibular aspect through the interproximal space of a pair of these teeth, *e g*, the mandibular premolars on one side, until only the eyelet is visible buccally, the ends then lying lingually One end of the wire is passed around the neck of one

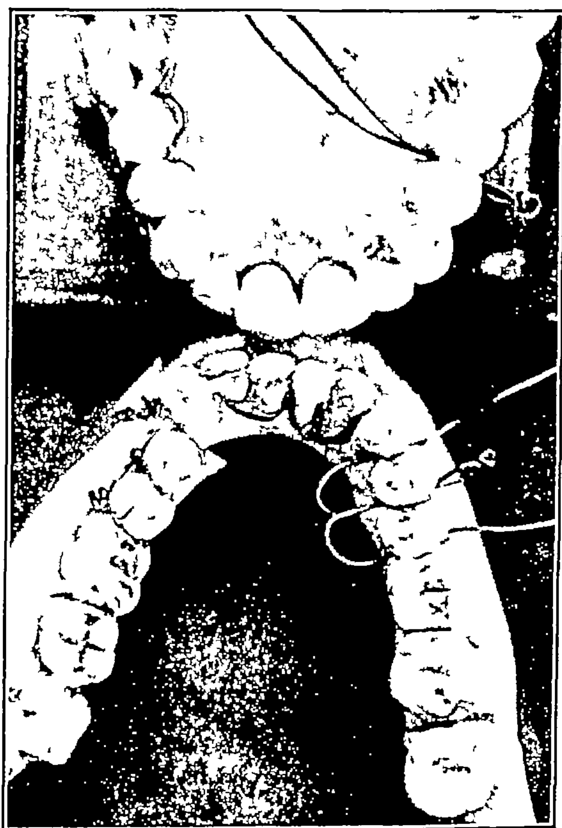


FIG 45 —Above Ends of eyelet wire passed between two premolar teeth Below Ends of eyelet wire passed around premolar teeth to emerge buccally

tooth and the other end around the neck of the other tooth so that both ends emerge on the vestibular aspect (Fig 45) One end of the wire is threaded through the eyelet lying between the teeth to prevent the eyelet from disappearing through the interproximal space and to give stability to the attachment (Fig 46) Each free end is grasped in a pair of hemostatic forceps and traction is made to draw the wire snugly around the necks of the teeth The ends of the wire are then twisted as tightly as possible It is very important that the first turn in twisting be made tight in order to get a firm attachment that will not appreciably loosen later All twists also should be made in one direction, *i. e*, from left to

right, so that one will know how to tighten the wires should it become necessary later Further tightening is done by grasping both ends of the wire with one hemostatic forceps, drawing the wire away from the teeth

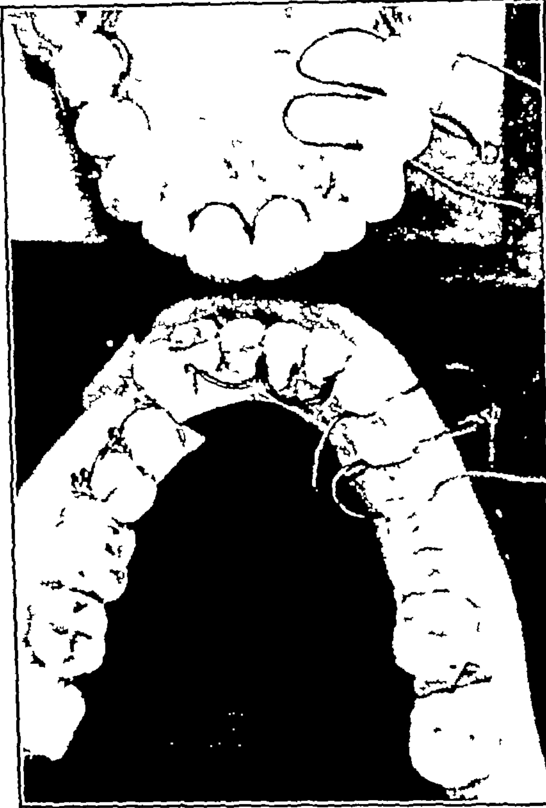


FIG 46 —Below One end of wire threaded through eyelet.

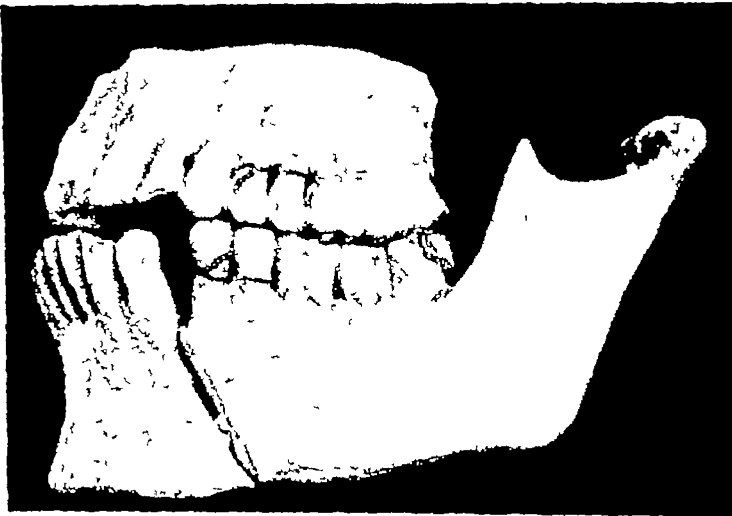


FIG 47 —Eyelet wires attached to upper and lower premolar teeth One end of wire is passed through projecting eyelet before twisting ends together to give more secure fixation (Surg Clin North America, W B Saunders Company)

and twisting carefully at the same time The ends of the wire are then cut off short and bent in against the teeth so as not to cut into the lips (Fig 47) Similar eyelet attachments are made to the corresponding

maxillary premolars, the mandibular and maxillary premolars of the opposite side, and the incisors in front. In the case of the mandibular incisors, the small size of these teeth makes it advisable to embrace all four of them by the wire loops Thus we have three points of attachment

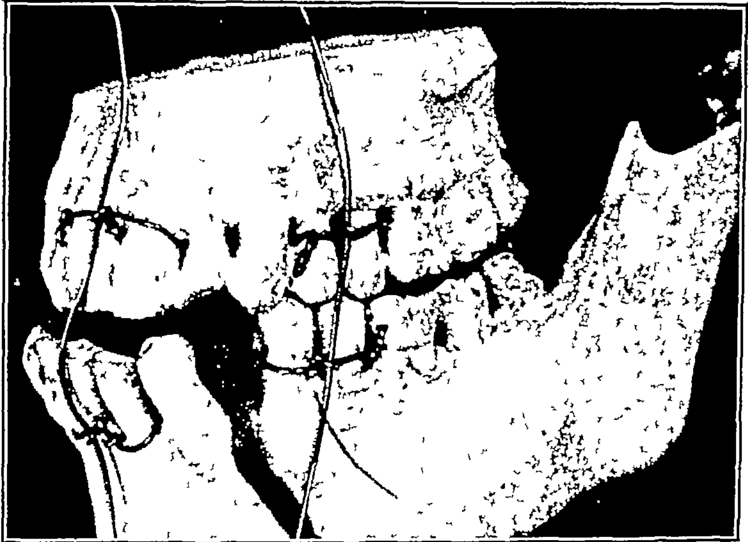


FIG 48 —Tie wires passed through mandibular and maxillary eyelets

for the mandibular teeth to those of the upper jaw, regardless of the location of the fracture, whether within the line of the teeth or posterior to the teeth Through each of the three pairs of eyelets is then passed a 12-inch single strand of the same No 24-gauge brass wire (Fig 48), the

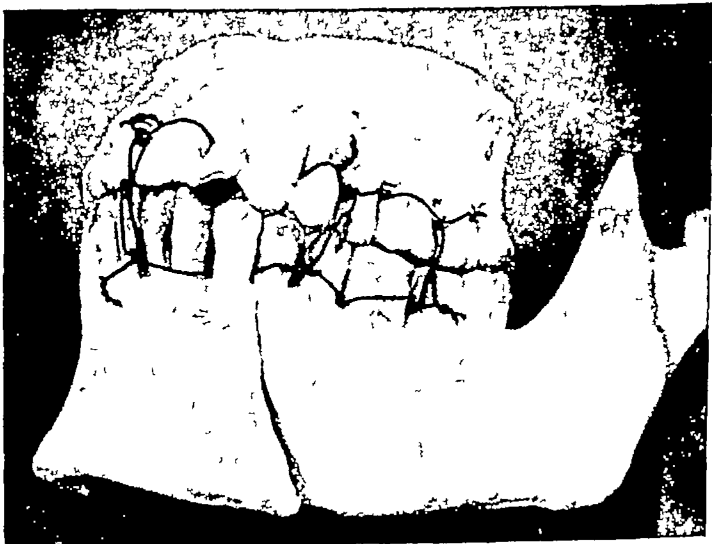


FIG 49 —Upper and lower pairs of eyelets connected by tie wires, which when tightened reduce fracture and fix teeth in occlusion (Surg Clin North America, W B Saunders Company)

patient is now instructed to bring the teeth together as nearly as possible and he is aided in this by the operator making gentle upward pressure on the chin As the upper and lower teeth come together, the ends of each

strand of wire passed through the eyelets are twisted together in succession, to hold the teeth firmly in occlusion The ends of the wires are cut off short (about $\frac{1}{4}$ inch), twisted more tightly with hemostatic forceps, and turned in, away from the cheeks and lips (Fig 49) Complete reduc-



Fig 50 —Fracture in right premolar region, showing typical displacement

tion may not immediately follow the first tightening of the wires, but will generally occur on taking up the slack of the connecting wires after twenty-four hours In some cases of displacement the desired movement of a fragment to restore proper occlusion can be produced by placing one of



Fig 51 —Same case as in Figure 50, ready for drawing up the wires

the upper eyelets in a position to right or left of the corresponding lower eyelet as the case may be, instead of directly opposite For success in this method a general knowledge of normal occlusion of the teeth is essential (see p 28, and Figs 21 and 22) Figures 50, 51 and 52 illustrate the use of this method on a patient If the teeth usually regarded as most suitable for attachment of the eyelet wires are not available, then other teeth may

be used, such as a canine and premolar, or a premolar and molar If possible, it is best to avoid wiring teeth next to the line of fracture At times two adjoining teeth may not be available at one point where it is essential to have an eyelet In this case a sufficiently firm attachment of an eyelet wire to a single tooth can sometimes be obtained by passing the wire around the neck of the tooth twice, with one end through the eyelet before twisting the ends together With attachment of the wires to at least three different points, the strain is well distributed and there is little tendency to loosening the teeth from this source A great advantage of this method is that if one wire breaks—usually a tie wire—it can be easily replaced without disturbing any of the eyelet wires The tie wires may be



Fig 52 —Same case as in Figures 50 and 51, after reduction

cut at any time to gain access to the inside of the mouth for any purpose, and replaced immediately The tie wires tend to loosen every few days, but can be easily tightened One objection that has been raised to this method is that it necessitates closure of the upper and lower teeth together, interfering with the mastication of food This disadvantage is offset by the better fixation of the fragments, better control of the patients, and more certain consolidation in good position Many patients thus treated carry on their usual occupations even while on liquid diet Instructions are given as to proper feeding of these patients in Chapter VIII

Alternative Method —In cases where the teeth are not sufficient in number and stability for direct application of the eyelet wires, we employ a plain German silver half-round arch wire moulded to conform to the vestibular surfaces of the teeth and attached to the latter with brass wire ligatures A similar arch is applied to the upper teeth and then the upper and lower arches are connected by the finer brass tie wires (Fig 53) These arches were first brought to the attention of the profession by Sauer in 1889 [30] He used heavy round iron wire for the arch, and ordinarily applied it to the mandibular teeth *only*, never employing absolute fixation by wiring the upper and lower teeth together in the closed bite position, but sometimes connecting upper and lower arches by elastic bands The influence of Sauer in treating fractures of the mandible without complete immobilization of the joint is still evident in the German school In

fractures posterior to the line of the teeth Sauer corrected deviation of the occlusion by soldering a buccal flange or inclined plane to the arch wire in the molar region on the sound side of the mandible This prevented the mandible from drifting over to the fractured side when the patient opened the mouth Gilmer was the first in this country to apply arches similar to Sauer's to both upper and lower teeth and connect the two with finer wires to fix the upper and lower teeth in occlusion He also employed the buccal flange or inclined plane The same principle is embodied in the orthodontic clamp bands devised by Loher in Germany and Angle in America, and now extensively used by Schroder, Hauptmeyer and others While recognizing the efficiency of these appliances, we find them more complicated in construction, more difficult to apply, and no more efficient

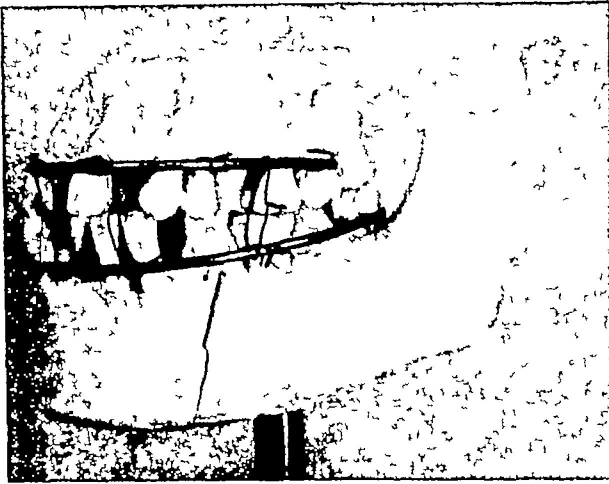


FIG 53 —Half-round German silver arch bars attached to upper and lower teeth, and connected by tie wire (Surg Clin North America, W B Saunders Company)

than the simple arches wired to the teeth by the method of Sauer and Gilmer We prefer for the arches a half-round German silver wire, 2 mm in width,* since its flat surface can be more accurately applied to the vestibular surfaces of the teeth than the round wire

In cases of fracture with considerable displacement it is often advisable to place a separate half-round wire arch on the teeth of each segment, until complete reduction has been obtained Then, when all of the lower teeth come into occlusion with the upper teeth, the separate arch wires can be replaced by a single arch embracing the teeth of all segments In cases of marked displacement, gradual reduction can be obtained by elastic traction on individual segments by means of small orthodontic rubber bands passed over the ends of the brass wires which fasten the arches to the teeth, these elastics running in the desired direction of pull from the lower to the upper arch This method of connecting the rubber bands does away with the necessity of soldering special hooks or lugs on the arch wires When reduction has been completed after a few days by the rubber bands, they can be discarded and the upper and lower teeth firmly fixed

* This 2 mm half-round German silver wire is made by the Blue Island Specialty Company, Blue Island, Illinois

in occlusion by connecting the upper and lower arches with 24-gauge brass tie wires (Figs 54 and 55) The method of applying the arches is as follows Where the entire upper or lower set of teeth is to be used, an arch wire about 5 inches long is required This can be bent with a strong pair of hemostatic forceps or pliers and contoured to lie in contact with the vestibular surfaces of all of the teeth Each end is curved so as to accurately pass well around the distal surface of the posterior tooth The arch is ligated to as many teeth as desired, *e g*, the two end teeth and two intervening teeth by 6-inch lengths of No 24-gauge brass wire Each

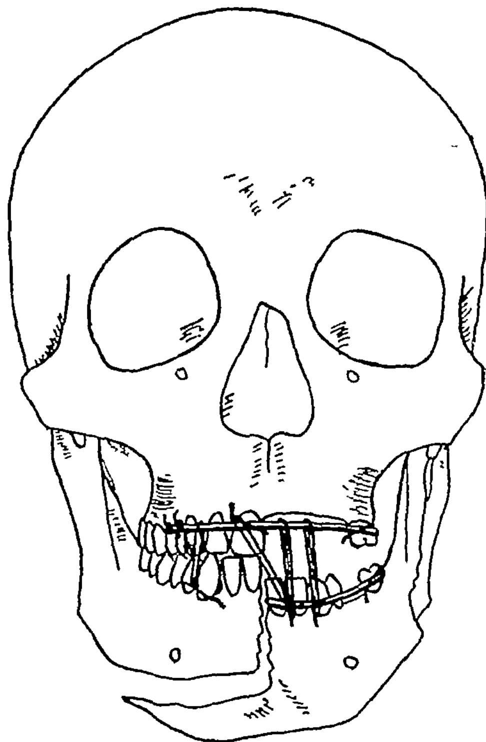


Fig 54 —Gradual reduction of depressed fragment by rubber bands connecting upper and lower arch wires (Ivy and Curtis Annals of Surgery)

ligature passes around the neck of the tooth, the ends emerging through the interproximal spaces to the vestibular aspect, one end passing above the arch and the other beneath it, the ends being then tightly twisted together over the arch, cut off short and bent over so as not to project into the cheek or lip When an unusual amount of stress has to be applied to the bars as, for example, in cases with a long standing displacement of the fragments and consequent difficulty in their proper reduction, or in fractures of the condyles with the usual open bite, it is best to ligate the arch to each tooth and to carry it well back on to the molar teeth, if possible This will help in preventing a possible loosening of the teeth in their sockets

It occasionally happens that the lower anterior teeth, upon which the heaviest duty often falls, particularly in open-bite deformities, are not amenable to the retention of a securely fixed arch bar This may be because of the faulty arrangement of the teeth, poor quality or insufficient

numbers This difficulty can be usually overcome by first ligating the arch bar to each tooth present and then securing the bar by circumferential wiring (page 84) Two strands of 24-gauge brass wire are twisted together, passed around the bone, brought over the bar and the ends twisted One or two of these double strands may be applied as the case demands

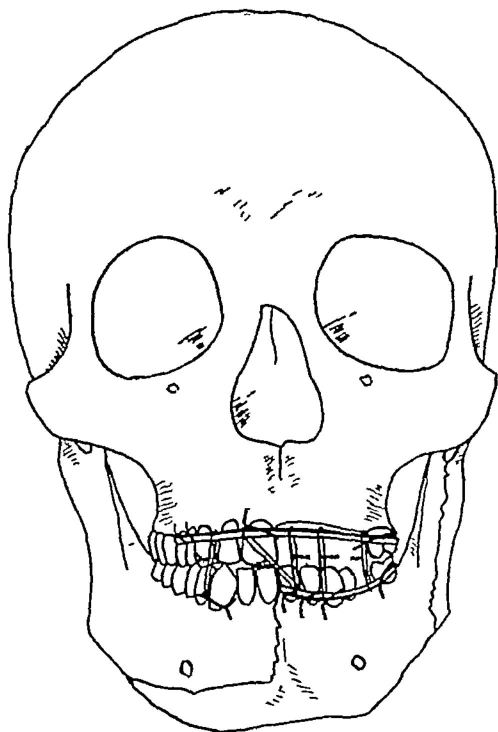


Fig 55 —Replacement of rubber bands by brass tie wires after reduction (Ivy and Curtis Annals of Surgery)

If rubber bands are to be used for connecting the upper and lower arches, they can be hooked over these twisted ends If the upper and lower teeth are to be fastened firmly in occlusion, several 12-inch strands of the No 24-gauge brass wire are applied around the upper and lower arches at different points, their ends twisted together and cut off short If additional firmness is desired, instead of using a single strand of tie wire, a separate wire can be twisted around the upper arch at a given point and another one around the lower arch at a corresponding point, and then these two wires twisted together The arch wire method is more difficult and takes more time to apply than the eyelet method, so we employ the former only when the latter is not applicable In some cases a combination of the two methods is used, the eyelets on one jaw and the arch wire on the other

The following is rather an unusual case, treated by the methods just described

T S , male, white, aged twenty-eight years, millwright November 15, 1929, while changing an automobile tire beside the road, was struck on the left side of the head by the fender of another car At the Lankenau Hospital a deep wound was found, beginning behind the left ear, and passing downward over the ascending ramus of the mandible of the neck.

The parotid gland and facial nerve branches were severed, and there a fracture of the mandible at the angle, the ascending ramus and condyle being dislocated forward and turned at right angles so that posterior border faced toward the left (Fig 56) First aid treatment

Fig 56





Fig 57

Fig 56 —Case T S Roentgenogram showing fracture of mandible through angle with rotation of ramus and dislocation of condyle

Fig 57 —Case T S Roentgenogram showing condyle replaced in normal position (Ivy and Curtis Annals of Surgery)

Dr Montgomery Deaver consisted in arrest of hemorrhage, suture of the ear, and fixation of the lower teeth to the upper by means of brass wires to control the main fragment of the lower jaw By November 30 the patient had recovered sufficiently to be transferred to our clinic for further

treatment The exposed bone of the ascending ramus had become almost entirely covered by granulation tissue, and practically no suppuration was present There was an almost complete left-sided facial paralysis The main fragment of the mandible was in fairly good position The wires on the teeth having worked somewhat loose, it was thought advisable to obtain firmer fixation by applying half-round German silver arches to the upper and lower teeth and in turn connecting these with No 24-gauge brass tie wires On December 12, at the Graduate Hospital of the University of Pennsylvania, under ether, the external wound was enlarged, exposing the outer aspect of the displaced ramus and condyle fragment,



Fig 58 —Case T S Showing opening of mouth after treatment



Fig 59 —Case T S Showing occlusion of teeth after treatment (Ivy and Curtis Annals of Surgery)

care being taken not to completely sever the bone from all soft tissue connections This fragment was then manipulated into correct position, the condyle being brought back to the mandibular fossa (Fig 57) The lower end of the ramus was brought in contact with the main part of the mandible at the angle, but no attempt at direct fixation was made The attachment of the bone fragment to the soft tissues was so precarious that we had little hope of saving it But we were very gratified to note a gradual healing over of the exposed portion of the bone with the exception of a small sequestrum near the angle, and on January 29, 1930, the external wound was almost closed On this date, the connecting wires between the upper and lower teeth were cut and almost complete union of the fragments had taken place There was good motion at the joint, the mouth opening being approximately normal, and the occlusion of the upper and lower teeth was satisfactory (Figs 58 and 59) There has been some improvement in the facial paralysis We expect later to smooth out the depression left in the healing of the wound, and possibly raise the left side

of the face by implantation of fascia lata strips This case well illustrates the success of conservatism in the presence of apparently hopelessly detached bone fragments

Intramaxillary Multiple Loop Wiring —This method of wiring for the reduction and fixation of fractures was developed by Colonel Roy A Stout, Dental Corps, United States Army We may consider the application of a single wire with multiple loops from a first molar tooth to the canine, inclusive For this purpose a 12-inch piece of 24-gauge brass ligature wire and a 2-inch piece of some 8-gauge pliable round wire are used For the latter it is convenient to adapt a piece of soft tubular solder, which comes on a spool, to the needed form If more teeth are to be included it will be necessary to use a longer piece of brass wire

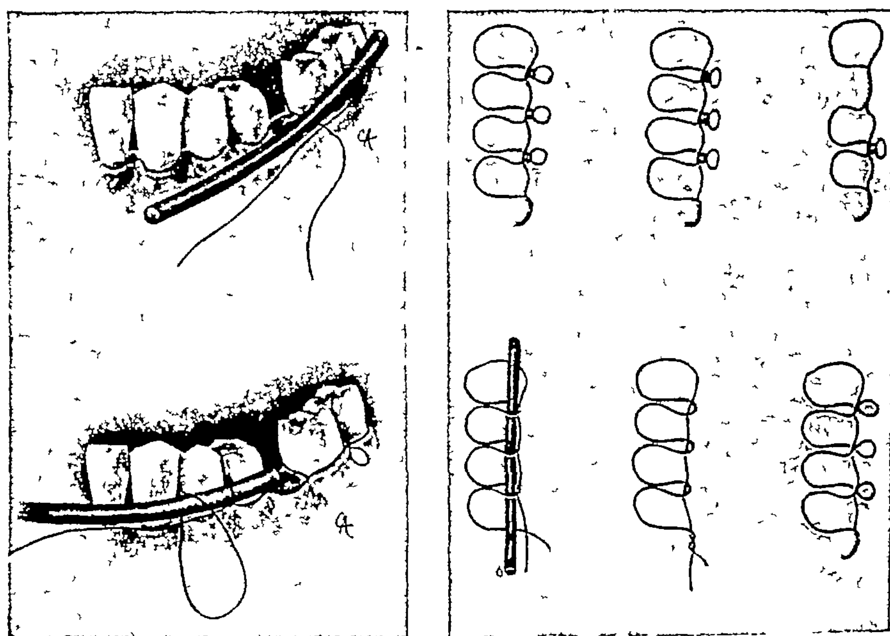


FIG 60 —*Left*, application of intramaxillary wiring, using 8-gauge lead wire as a guide in forming the loops, *right*, relation of the wire and loops to the teeth (teeth removed) (Manual of Plastic and Maxillofacial Surgery, W B Saunders Company, p 274)

Technique and Application —We cannot improve on the description to be found on pages 274–276 in the Manual of Standard Practice of Plastic and Maxillofacial Surgery[21] "The wire is first threaded through the interproximal space between the first and second molars, from the lingual aspect The wire is pulled through buccally and forward, along the buccal surface of the teeth as far forward as the lateral incisor, allowing sufficient length for the final twisting of the ends at the mesiofacial angle of the canine The long lingual end is threaded through the interproximal space mesial to the first molar, passing gingivally to the wire lying along the buccal surface of the teeth The long end is bent back on itself and is threaded through the same interproximal space, forming a loop encircling the short buccal strand At this point the end of the lead wire, gauge 8, and about 2 inches (about 5 cm) long, is inserted in the loop and held

parallel with the buccal wire and in contact with the buccal aspect of the teeth (Fig 60) The lingual wire is now pulled tightly, giving the loop its proper form, size, and correct relation to the buccal wire and the teeth The lingual wire is then threaded through the next interproximal space (between the premolars), passing above the buccal wire and the lead wire, the end again is returned through the same interproximal space, forming the second loop (encircling the lead wire and buccal strand) In the same manner the next loop is made between the first premolar and the canine and the lingual end drawn tightly so that the lead wire is held rigidly against the buccal surfaces of the teeth The lingual wire is now threaded through the interproximal space between the canine and lateral incisor and again drawn tightly Pull is exerted forward (mesially) on the buccal wire, with the same tension as on the other end. This will draw the loops all up into their proper position and give them the desired uniform size The lead wire is now removed by rotating slightly and moving it forward this is easily done by grasping the anterior end with pliers or the fingers

"The ends are now grasped with the pliers and twisted a few times so as to stabilize the wire and to bring the twisted portion to rest on the mesiofacial angle of the canine The posterior loop is grasped with smooth-beak (No 122) pliers and twisted three-fourths of a turn, which will place the loop in a horizontal position, bringing the buccal wire slightly into the embrasure The other loops are treated in the same manner This adapts the wire well around each tooth Starting again with the twisted ends, they are given the final adjustment, twisting is continued until the wire fits the mesiofacial angle snugly The excess twisted ends are cut off and neatly adapted against the mesial aspect of the tooth as well as into the embrasure On occasion these twisted ends can be carefully adjusted and used as an additional hook The next adjustment of the loops is accomplished by giving each one an additional half turn, which gives the wire the final adjustment around each tooth, carries the buccal wire closer into the embrasure, and secures the loops in their proper position The final adjustment of the loops is to bend them gingivally so that they are in light contact with the gingiva and can be used as hooks for elastic traction (Fig 61) Then, by use of small elastic bands, both intramaxillary and intermaxillary traction and fixation can be obtained as desired The requirements of stable anchorage with a broad base involving a number of teeth have been fulfilled Likewise, application of the wire can be quickly accomplished and manipulation of the parts reduced to a minimum

"*In Presence of Edentulous Portions* —In case these are encountered, the formation of loops can be interrupted and the wire twisted to bridge the spaces The twisted wire strand that bridges the space assists in stabilization of the teeth in that arch and provides point of anchorage for intermaxillary elastic bands"

Another form of arch bar is that developed by Risdon of Toronto, Canada [28a] It is not a substitute for the heavier half-round German silver bars in cases of loose or missing teeth, or when strong traction is required, but can serve a useful purpose where most of the teeth are

present and firm and when some appliance is needed which will carry a heavier load than the separate eyelet loops and will divide the stress among more teeth It automatically adapts itself to the buccal and labial surfaces of the teeth when ligated to them whereas the half-round bar must be carefully fitted to each tooth with pliers (crown-bending pliers are the best), thus consuming much more time in its construction

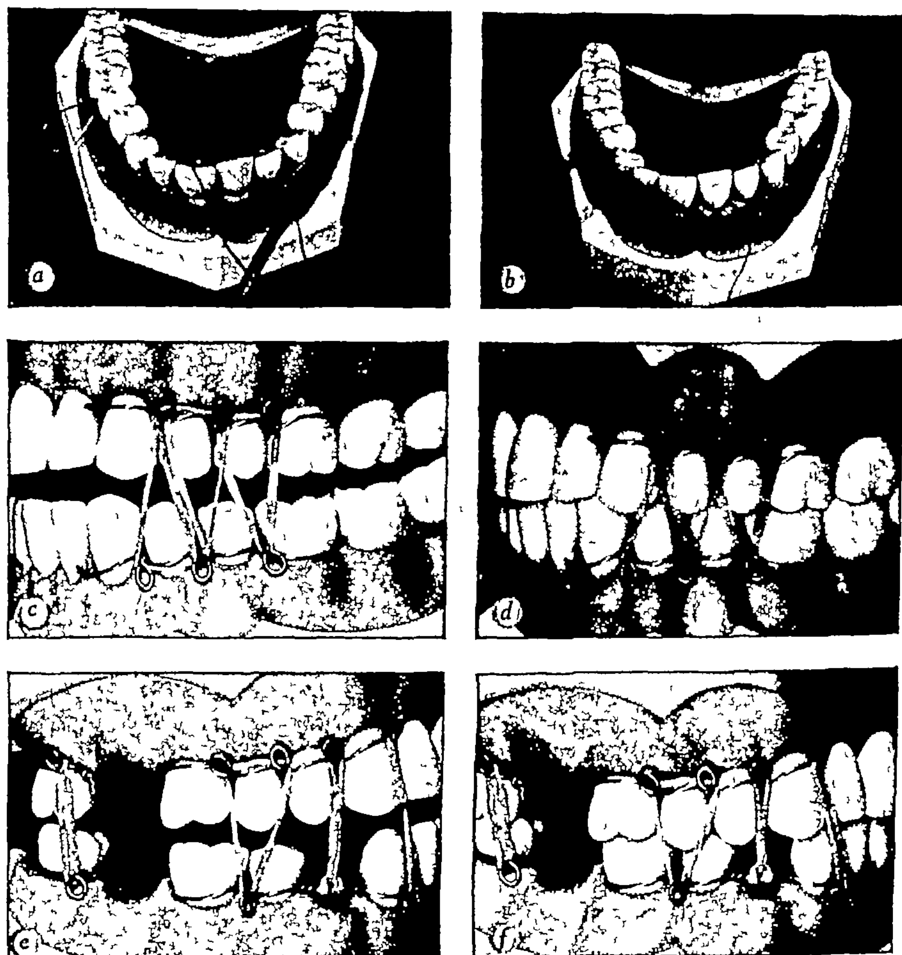


Fig 61 —*a* and *b*, Steps in application of multiple loop wiring to models, *c* and *d*, multiple loop wiring on models, illustrating application of elastic bands forming a triangle, with base in one arch and apex in the other, *e* and *f*, application of the loops to single teeth and the method of twisting wire to bridge edentulous portions of the jaws (Manual of Plastic and Maxillofacial Surgery, W B Saunders Company, p 275)

A 12-inch strand of 24-gauge brass ligature wire is passed around a first molar tooth and the two ends, of equal length, twisted firmly with two turns by the fingers on the mesiobuccal angle at the gingival border (Fig 62) The wire is further secured around the neck of the tooth by grasping the twisted portion with pliers and giving it a half turn The two ends are then grasped by the fingers and twisted so that, when applied along the buccal and labial surfaces of the teeth, the twisted portion will extend half an inch beyond the midline of the jaw A second wire is similarly applied to the molar of the opposite side and the ends twisted

to the proper length These two parts are then twisted with the fingers at the midline, leaving the free ends temporarily long, thus forming a con-

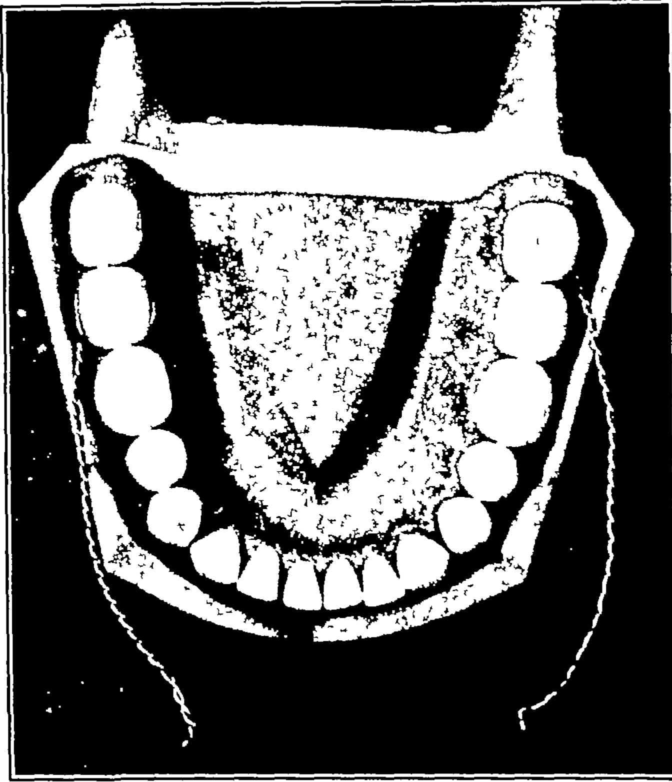


Fig 62 —Risdon's method of wiring teeth, 1st step (see text)

tinuous arch bar from molar to molar (Fig 63) It is then ligated securely to each tooth, the free ends cut to leave a four-strand twist, a quarter of an inch in length, which can be tightened with the pliers to make the entire

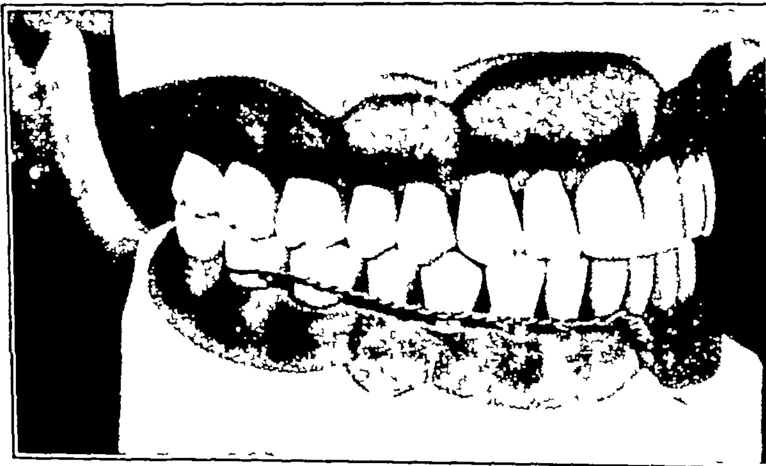


Fig 63 —Risdon's method, 2nd step

bar taut (Fig 64) If elastic traction is to be used the individual twists at each tooth can be turned gingivally and the rubber bands hooked over them If the lower jaw is to be immobilized it is fixed to the upper jaw by the usual connecting wires

It sometimes happens in either jaw that the fragments are separated and it is difficult to restore the normal contour of the arch For example; —a median, vertical fracture of the upper jaw through the hard palate. By using this type of appliance one can exert a considerable amount of pressure to approximate the fragments by tightening the 4-strand twist in the midline We usually like to reduce and fix each fragment in the lower jaw independently, but it is sometimes expedient to bring together stubborn fragments in this manner

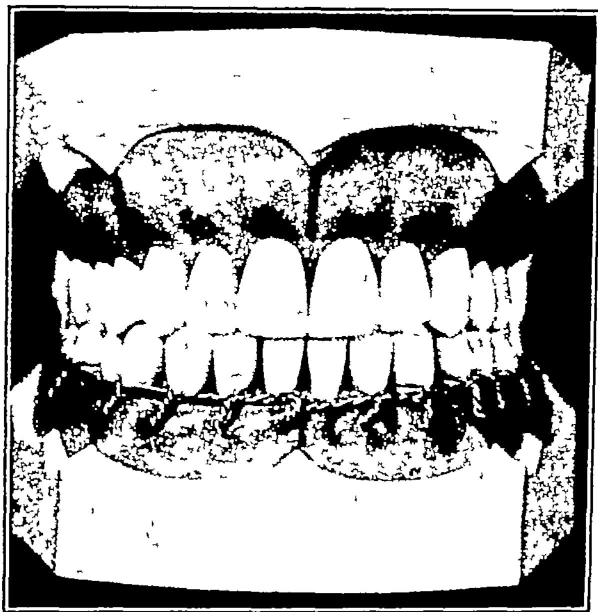


FIG 64 —Risdon's method, completed, on lower teeth

The treatment of *fracture of the neck of the condyle* requires special mention Recent communications on the subject have been made by Silverman,[33] Aison,[1] Zemsky,[37] Boon[6] and Bonney [5] There seems to be a general feeling that when the head of the condyle is displaced at the time of fracture, unless something radical is done to replace the head, dire results such as ankylosis and deformity will follow Hence, the proposed open operations of Silverman and Aison That displacement of the head of the condyle is not rare in these fractures is shown by the fact that in 5 cases seen the head was drawn forward and inward by the external pterygoid muscle in 3 None of these cases had an open operation, either intra-oral or extra-oral, none had any special manipulation to put the condyle back in position, and all recovered with good function, without ankylosis or deformity Zemsky, with the same ungrounded dread of ankylosis in mind, advises treatment of all cases by mobility instead of immobilization On the other hand, we have successfully treated all cases, with or without displacement of the head of the condyle, where it was possible to restore immediately the normal occlusion of the teeth, by fastening the upper and lower teeth together in occlusion for three to five weeks, and have never seen a case result in ankylosis. Occasionally, where

there is considerable shortening of the affected side, characterized by marked deviation of the lower teeth to that side, it is of advantage to open the bite posteriorly on that side by interposing a layer of base-plate gutta percha between the molar teeth before fastening the teeth in occlusion. This tends to increase the length of the jaw on the fractured side, so that when union takes place there will be no deviation[18]

The treatment by mobility from the start presents a certain element of danger, not of ankylosis, but of resulting in a permanent shortening of



Fig 65 —Fracture through neck of left condyle, with deviation of mandible to left Gradual reduction by elastic traction

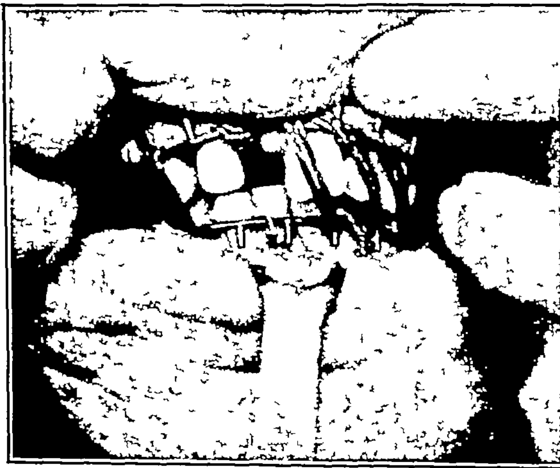


Fig 66 —Same case as in Figure 65, reduction practically complete

the fractured side of the jaw with a deviation to this side and malocclusion of the teeth This is illustrated by a case treated at a hospital for four weeks following the injury by use of a Barton bandage which did not produce immobilization but accentuated the displacement by drawing the chin backward When seen by the writers fibrous adhesions made immediate reduction to proper occlusion impossible This was then dealt with by arch wires connected by intermaxillary elastics, bringing about gradual reduction (Figs 65 and 66) It may be safely stated that ankylosis

only follows injuries to this region when the fracture involves the joint surfaces, especially in young children, or in compound fractures with suppuration in or around the joint In these cases, operative measures may become necessary to overcome ankylosis But in the usual case of fracture at the neck of the condyle, with or without displacement of the head, the usual methods of fixation by wiring the teeth in occlusion will almost invariably give a good result, and we regard operative interference as unwarranted

Fracture of the coronoid process requires no treatment except a short period of immobilization by wiring the upper and lower teeth together, until the acute discomfort occasioned by attempts at movement of the jaw has passed This may require one week or two weeks, after which movement should be encouraged to overcome any tendency to formation of adhesions

Additional Methods of Treatment for Special Cases —At least 90 per cent of all fractures of the mandible, regardless of their position, can be successfully treated by the methods described above Certain cases occur, however, in which modifications or additions become necessary Nearly all of these complications are due to absence of teeth from the mandible or from the upper jaw

Among the commonest of these special cases are

1 Fracture in molar or premolar region with long edentulous posterior fragment

2 Fracture in molar or premolar region with teeth in posterior fragment but no opposing teeth in upper jaw

3 Fracture of edentulous or almost edentulous mandible

4 Fracture of mandible with edentulous upper jaw

5 Comminuted fracture at symphysis with loss of incisor teeth and bone

6 Fracture of mandible complicated by fracture of maxilla

1 *Fracture in Molar or Premolar Region With Long Edentulous Posterior Fragment* —One of the commonest difficulties in the treatment of fracture of the mandible is the control of a long edentulous posterior fragment In a fracture behind the last existing tooth, if this be a second or third molar, the posterior fragment requires no special fixation as a rule In this case, if the teeth of the lower jaw are brought in proper occlusion with those of the upper and held there, the short posterior fragment, although it may be slightly out of position, may be disregarded so long as union occurs with good occlusion of the teeth On the other hand, if the last existing tooth is a first molar or a premolar, and the fracture is just posterior to this, making a long edentulous posterior fragment, the latter will usually be pulled upward and sometimes inward by the elevator muscles of the jaw, until the overlying soft tissues meet the occlusal surfaces of the upper molar teeth, and there may be a concavity in the external contour of the face (Figs 26 and 67) If union of the fracture occurs in this position, the normal space between the upper and lower jaws in this region will be obliterated, with attendant difficulties in artificially bringing about a

good occlusion Also, the malposition of the fragments frequently leaves such small portions of the bone ends in contact as to delay or interfere with union We have tried the interposition of metal, vulcanite or other material in the mouth, to keep down the elevated fragment, but this frequently produces marked irritation or even pressure necrosis of the sensitive gum tissue.



FIG 67 —Roentgenogram showing elevation of edentulous posterior fragment

One of the most satisfactory ways of overcoming this upward and inward displacement has been recently suggested by Darcissac,[19] and we have employed it with success in several cases Through small skin incisions each angle of the mandible is exposed and a hole drilled through it for the passage of a No 24-gauge brass wire (Fig 68) Each wire

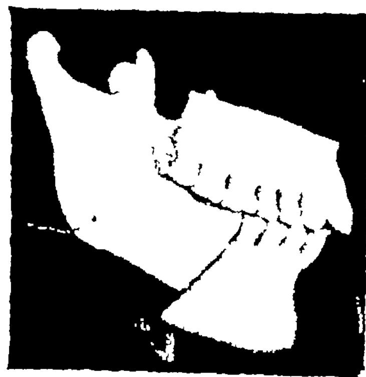


FIG 68 —Wire passed through hole drilled in angle of mandible to control edentulous posterior fragment (Ivy and Curtis Dental Cosmos, S S White Mfg Co)

emerges through the skin wound and is connected with its fellow of the opposite side around the back of the patient's neck by a heavy elastic band (Fig 69) This makes sufficient traction to overcome the upward

muscular pull and hold the edentulous fragment down and out in satisfactory position. The wire produces no untoward irritation in the soft tissues, and may be allowed to remain for several weeks. This method has the disadvantage of requiring an incision and drilling a hole through the angle of the jaw on the sound side. (In justice to Darcissac it must be



FIG. 69.—Darcissac's method of controlling edentulous posterior fragment. (Ivy and Curtis: Dental Cosmos, S. S. White Mfg. Co.)

said that he recommended the method primarily for bilateral fractures.) Wassmund[36] obviates this by connecting the wire passing through the hole in the bone on the fractured side by means of an elastic band to a broad leather or cloth band at the back of the neck. On the sound side

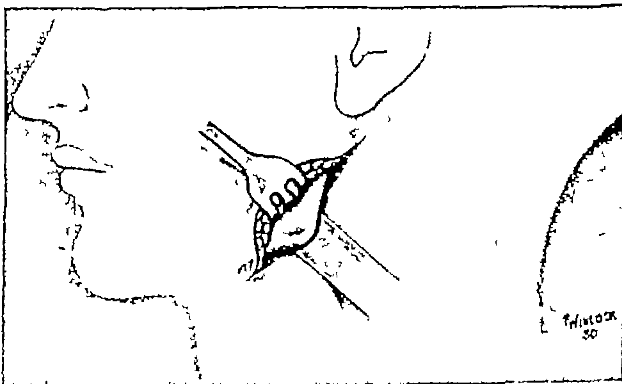


FIG. 70.—Incision exposing angle of mandible. (Ivy and Curtis:[16] Surg. Gynec. and Obst.)

the end of the neck band is connected to an extra-oral wire bow fastened to the teeth. We find that a comparatively simple and efficient way to produce traction on the posterior fragment is to connect the wire coming from the angle of the jaw by a heavy elastic band to a hook on a plaster of Paris head cap (Figs. 70, 71, 72 and 73). This achieves the desired result

just as well as the more elaborate nail-extension appliances described by Lindemann and others[36] The construction of a very satisfactory head cap has been described by Scogin,[32] whose technique we here reproduce *

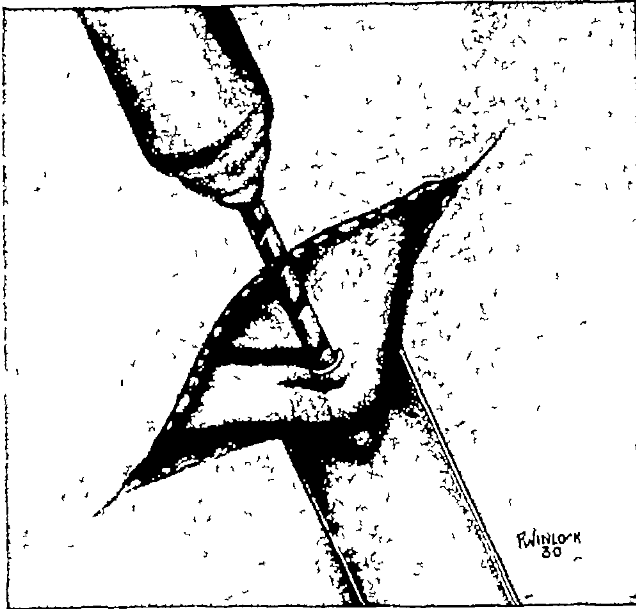


Fig 71 —Drilling hole through angle of mandible (Ivy and Curtis Surg , Gynec and Obst)

Plaster of Paris Head Cap —Materials necessary for construction

1 *Stockinette* (3 inches x 2 feet) Three-inch stockinette is 6 inches in circumference and capable of considerable stretching If not available,

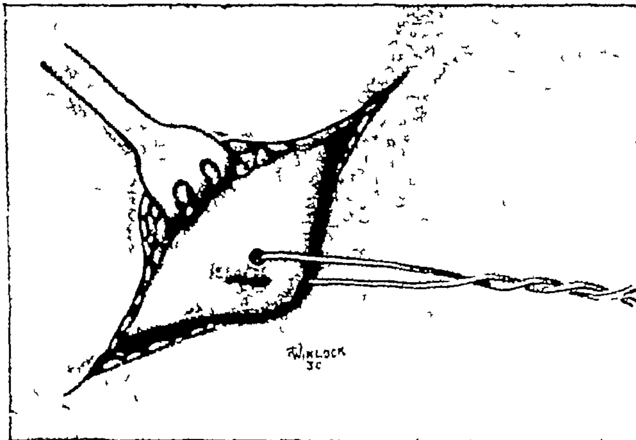


Fig 72 —Wire passing through hole in angle of mandible (Ivy and Curtis Surg , Gynec and Obst)

any substitute may be used, such as a leg from a pair of balbriggan drawers or a heavy white stocking

2 *Narrow gauze bandage or tape* 1 foot long

3 *Adhesive plaster* 1 inch wide

* Scogin, C W Internat Jour Orthodont , Oral Surg and Rad , 14, 526, 1928 Courtesy of C V Mosby Company

muscular pull and hold the edentulous fragment down and out in satisfactory position The wire produces no untoward irritation in the soft tissues, and may be allowed to remain for several weeks This method has the disadvantage of requiring an incision and drilling a hole through the angle of the jaw on the sound side (In justice to Darcissac it must be



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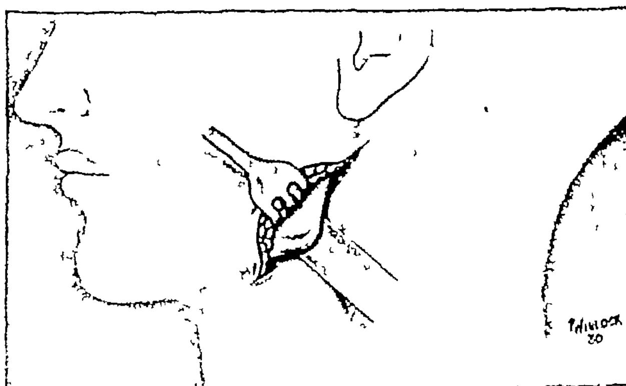


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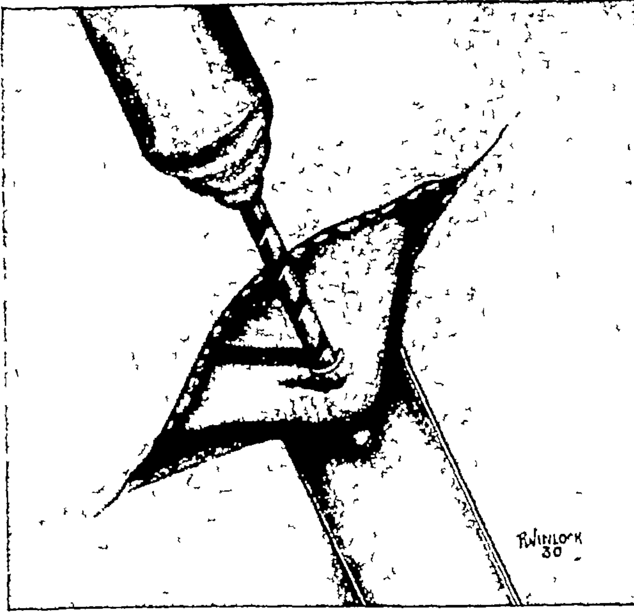


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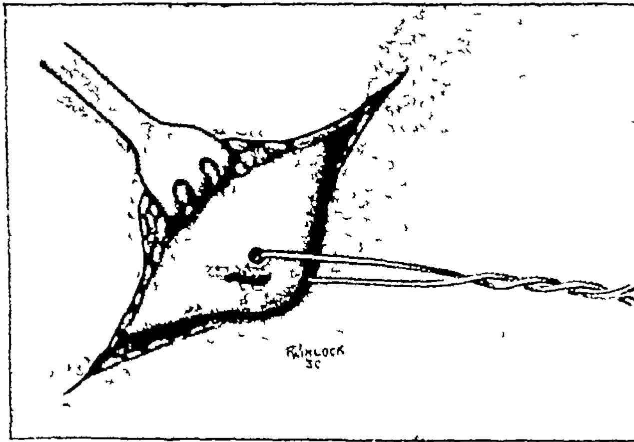


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2 *Narrow gauze bandage or tape* 1 foot long

3 *Adhesive plaster* 1 inch wide

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4 *Orthopedic felt* 4 (or more) strips—1½ inches x 6 inches If not available, use strips of heavy cotton batting or several layers from an old felt hat

5 *Plaster of Paris bandage* 2½ inches x 10 feet Two of these are necessary

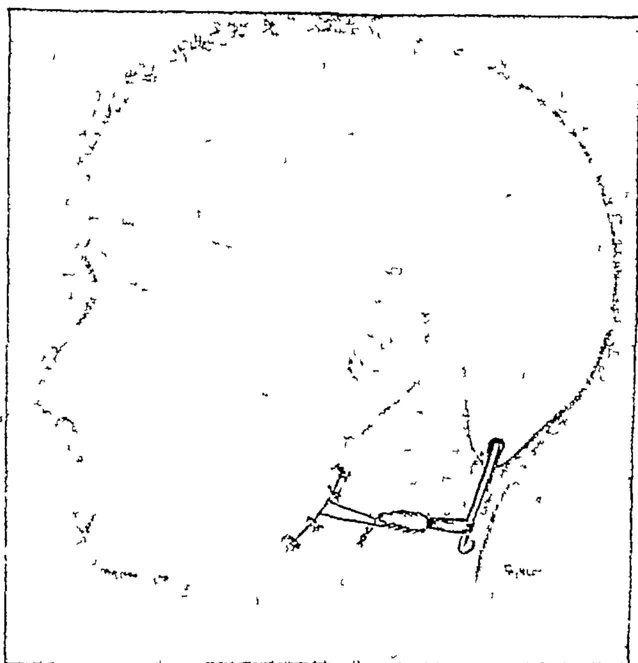


FIG 73 —Wire from angle of mandible connected with elastic band to hook on plaster head cap (Ivy and Curtis Surg, Gynec and Obst)

6 *Plaster of Paris* (good quality model plaster) large plaster bowl and heavy spatula

7 *Traction appliances* leather straps and buckles, hooks, loops, webbing, etc, as indicated Hooks can very conveniently be made from an ordinary wire coat hanger

8 *Scissors* bandage scissors for felt, small scissors for other materials

Outline of head areas to be utilized The direction of stress must necessarily determine the anchorage area In general, the finished margins of the cast should extend

1 Occipital region Well over the external occipital protuberance toward the base of the skull

2 Mastoid region As close as possible to the ears but not encroaching on them

3 Temporal region To about the zygomatic arch Definitely below parietal eminences

4 Frontal region Care must be exercised in freeing forehead to about 1 inch above eye-brow line

Construction steps 1 Seat patient in straight-backed chair without headrest

2 Clip hair on men if the case is to require lengthy fixation (two or more months)—otherwise not considered necessary Have women braid hair and arrange in loose coil on top of head

3 Apply one end of stockinette over head to a point 2 inches below previously determined border outline of finished head cap (Fig 74)

4 Tie narrow bandage or tape loosely around stockinette at top of head so that the loop will be about 2 inches in diameter

5 Cut slit in stockinette and push tied ends of tape through to inside This is done so that stockinette may be tightened during later treatment if necessary

6 Cut and adjust felt strips, one (or more) in each quadrant, and fasten in place on stockinette with adhesive plaster

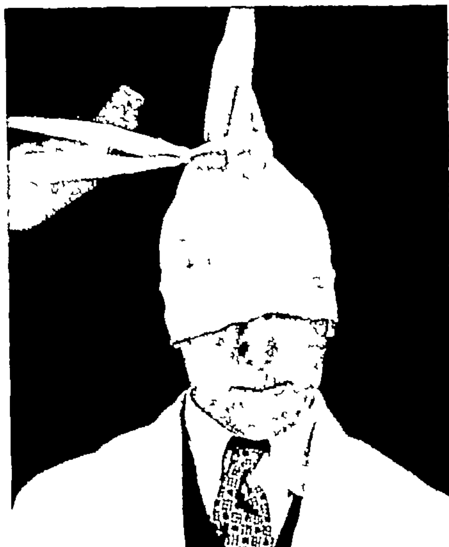


Fig 74 —Construction of plaster of Paris head cap Application of first layer of stockinette, and tying with bandage at top of head (Ivy and Curtis Surg Clin North America, W B Saunders Company)



Fig 75 —Application of strips of orthopedic felt in four quadrants and drawing down of second layer of stockinette, leaving felt strips between two layers (Ivy and Curtis Surg Clin North America, W B Saunders Company)

7 Pull free end of stockinette down over head and trim just short of the length of the first layer Felt strips are now between layers of stockinette There is a small opening at top of head in which the ends of the cord are found (Fig 75)

8 Apply first plaster bandage Wet bandage in lukewarm water and apply as a head bandage over stockinette, keep bandage wet, and smooth into place with wet hands, being certain to obtain desired outline form (Fig 76)

9 Apply plaster wash over this layer, smoothing well with wet hands

10 Turn up both ends of stockinette to form the lower border of cap, plastering the stockinette into plaster wash

11 Insert traction appliances as indicated for case, *i e*, straps, hooks, loops, etc These must be so placed as to deliver the correct directional force for the individual case (Fig 77)

12 Apply second plaster bandage in same manner as before, except that the lower ½ inch of stockinette is left exposed to produce a smooth, rounded border that will not cause irritation or crack during extended usage (Fig 78)

4 *Orthopedic felt* 4 (or more) strips—$1\frac{1}{2}$ inches x 6 inches If not available, use strips of heavy cotton batting or several layers from an old felt hat

5 *Plaster of Paris bandage* $2\frac{1}{2}$ inches x 10 feet Two of these are necessary

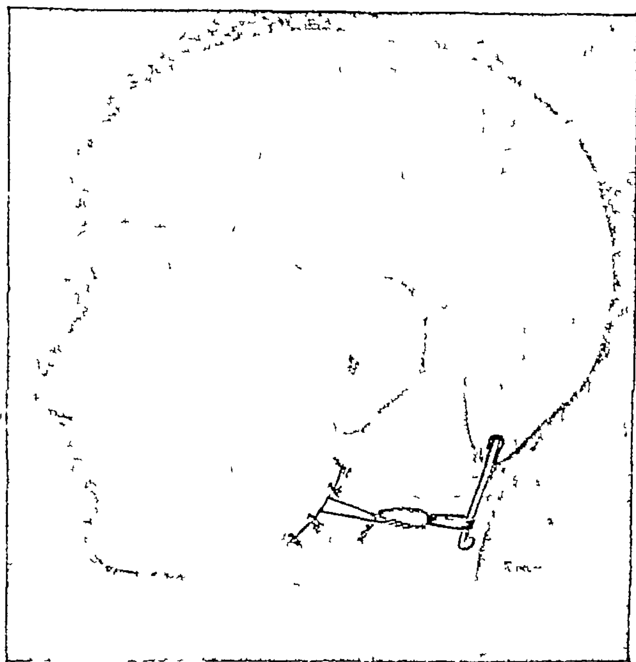


FIG 73 —*Wire from angle of mandible connected with elastic band to hook on plaster head cap* (Ivy and Curtis Surg, Gynec and Obst)

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5 Cut slit in stockinette and push tied ends of tape through to inside This is done so that stockinette may be tightened during later treatment if necessary

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FIG 74 —Construction of plaster of Paris head cap Application of first layer of stockinette, and tying with bandage at top of head (Ivy and Curtis Surg Clin North America, W B Saunders Company)

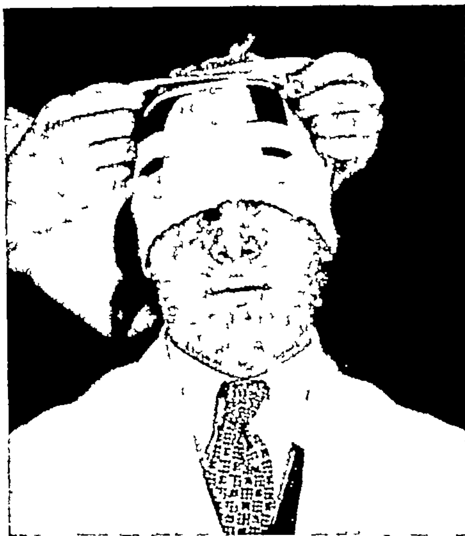


FIG 75 —Application of strips of orthopedic felt in four quadrants and drawing down of second layer of stockinette, leaving felt strips between two layers (Ivy and Curtis Surg Clin North America, W B Saunders Company)

7 Pull free end of stockinette down over head and trim just short of the length of the first layer Felt strips are now between layers of stockinette There is a small opening at top of head in which the ends of the cord are found (Fig 75)

8 Apply first plaster bandage Wet bandage in lukewarm water and apply as a head bandage over stockinette, keep bandage wet, and smooth into place with wet hands, being certain to obtain desired outline form (Fig 76)

9 Apply plaster wash over this layer, smoothing well with wet hands

10 Turn up both ends of stockinette to form the lower border of cap, plastering the stockinette into plaster wash

11 Insert traction appliances as indicated for case, *i e*, straps, hooks, loops, etc These must be so placed as to deliver the correct directional force for the individual case (Fig 77)

12 Apply second plaster bandage in same manner as before, except that the lower ½ inch of stockinette is left exposed to produce a smooth, rounded border that will not cause irritation or crack during extended usage (Fig 78)

13 Apply second plaster wash—smooth well with wet hands (Fig 79) After allowing to dry thoroughly, the head cap can be varnished if desired

In utilizing the head cap for control of the long edentulous posterior fragment of the mandible, a piece of coat-hanger wire is embedded in the



FIG 76 —Application of first layer of plaster of Paris bandage



FIG 77 —Insertion of various traction appliances over first layer of plaster bandage

plaster so that its projecting end, curved backward to form a hook, emerges just posterior to and below the ear Backward traction on the bone fragment is made by connecting the brass wire through the angle of the



FIG 78 —Incorporation of traction appliances in plaster of Paris bandage (Ivy and Curtis Surg Clin North America, W B Saunders Company)



FIG 79 —Head cap completed

mandible to the hook with a strong elastic band The amount of backward pull can be easily regulated The larger mandibular fragment is fixed by connecting the lower to the upper teeth with eyelets or arches in the usual manner (Fig 73)

Figures 80 to 83 Illustrate a Case Treated by this Method



Fig 80 —Radiograph showing fracture in front of right angle of mandible with displacement of lower end of posterior fragment inward and upward

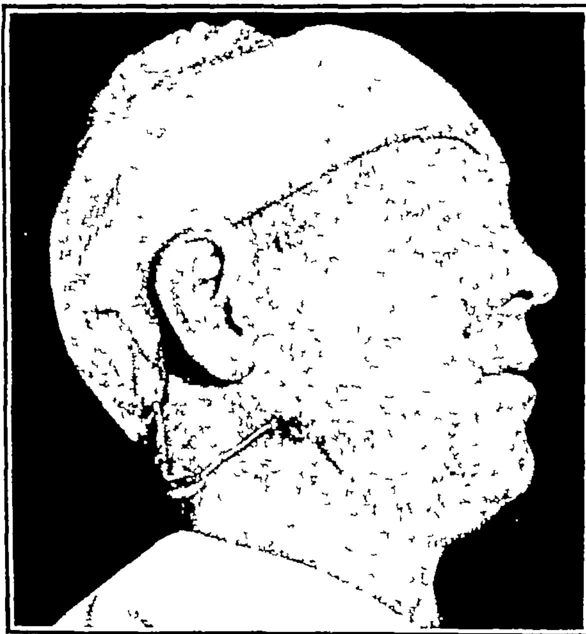


Fig 81 —Shows extension on posterior fragment by wire passed through angle to hook of plaster head cap

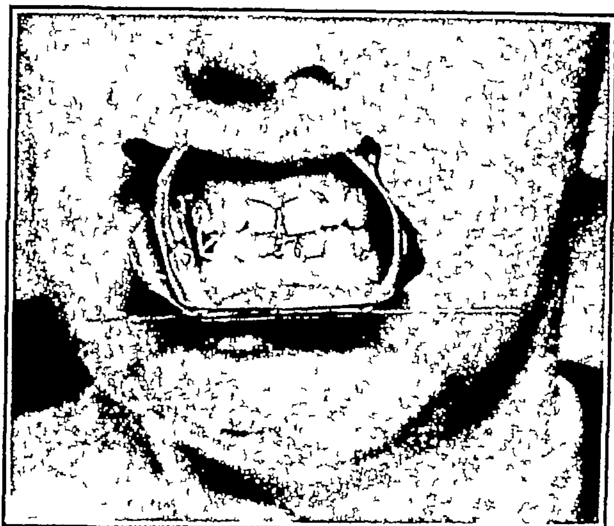


FIG 82 —Shows teeth on main fragment of mandible wired to upper teeth in correct occlusion



FIG 83 —Radiograph showing wire passed through angle holding posterior fragment held out and back in good position The main fragment of mandible fixed by wires on teeth Gap in between fragments will fill in with new bone

2 *Fracture in Molar or Premolar Region With Teeth in Posterior Fragment But No Opposing Teeth in Upper Jaw*—Here, the same tendency exists for the posterior fragment to ride up out of position, and it can be treated in exactly the same manner as the previous case. An alternative

method is to have constructed for the upper jaw a vulcanite piece after the manner of a partial denture, the vulcanite being built up on the side of the missing molars to hold down the molar teeth in the posterior man-

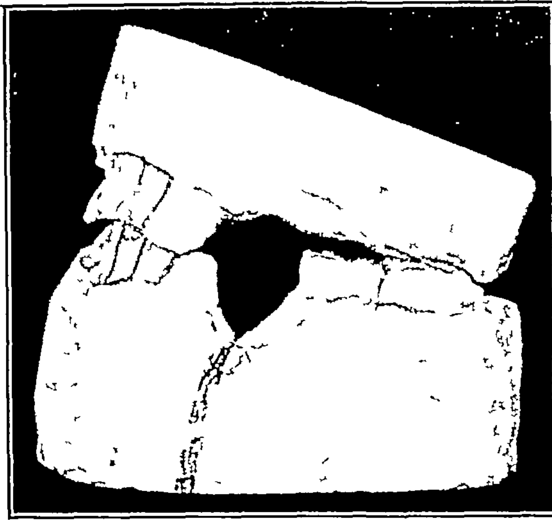


FIG 84 —Fracture in premolar region with teeth in posterior fragment but no opposing maxillary teeth

dibular fragment After insertion of the vulcanite piece, the lower teeth on the long mandibular fragment are fastened in occlusion to the upper teeth (Figs 84, 85, 86 and 87)

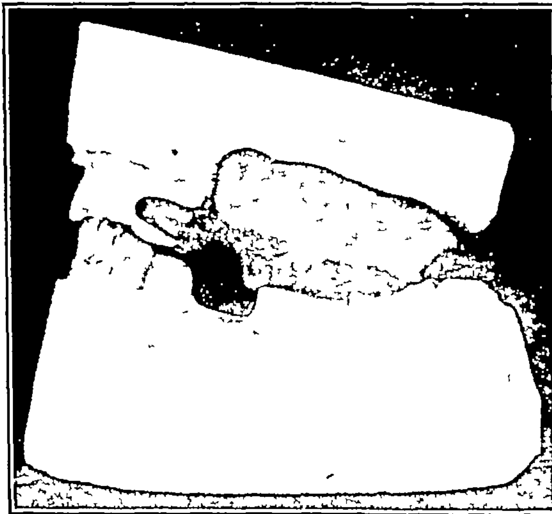


FIG 85 —Same case as in Figure 84, after insertion of upper vulcanite plate with bite block to keep down mandibular teeth

Skeletal Fixation —In recent years the principle of direct fixation of mandibular fragments by means of pins drilled into the bone through the skin and linking the pins with a rigid bar externally, has been applied to fractures of the mandible This principle was probably first employed in fractures of the long bones by Parkhill,[25 26] of Denver Figs 88 and 89 show Parkhill's "bone clamp" as illustrated on one of his articles, and

indicates a close resemblance to appliances at present in use Roger Anderson[2] is largely responsible for the present popularity of this principle in treatment of fractures of the long bones Application of the method to mandibular fractures is to be credited to many workers Waldron[35] has fully described the various modifications in use at the present time

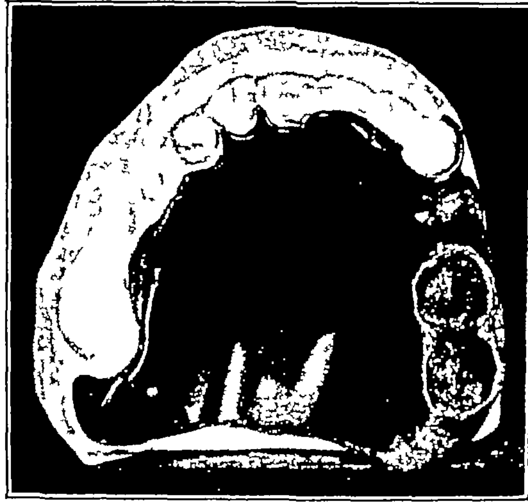


Fig 86 —Palatal aspect of appliance shown in Figure 85

One of the earliest applications of this principle to mandibular fractures is that of Pickerill[28] during World War I In 1940 Bigelow[3] described the use of a series of slotted vitallium screws inserted into the lower border of the mandible through the skin After reduction of the fracture the fragments are fixed by connecting the screw heads with a rigid bar externally,

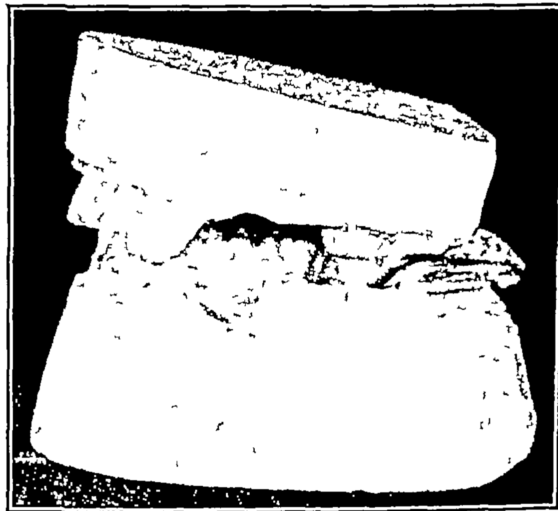


Fig 87 —Same case as in Figures 84 to 87, after treatment, showing good alignment of teeth

reinforced with plaster if necessary Griffin[14] adapted the Haynes apparatus to fractures of the mandible It consists of two parallel screws drilled into each fragment through the skin, the unit on each fragment being connected, after reduction, by a rigid bar Several British workers have devised modifications of the Roger Anderson principle, with addition of

universal joints to permit greater flexibility of application and facilitate reduction Among these may be mentioned Mowlem,[22] Gillies,[10] Converse and Waknitz,[7] Rushton and Walker [29] In the United States may be mentioned the apparatus of Stader,[20] Waldron[34] and Parker,[24] both have described an apparatus in which the universal joints are taken from a

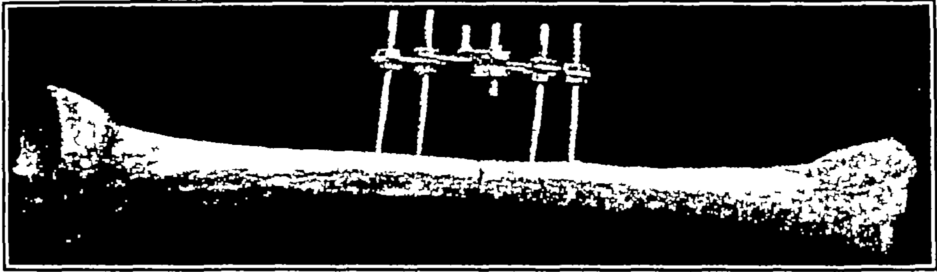


Fig 88 —Parkhill's "bone-clamp" in tibia, side view (Trans Am Surg Assn , 15, 251–256, 1897)

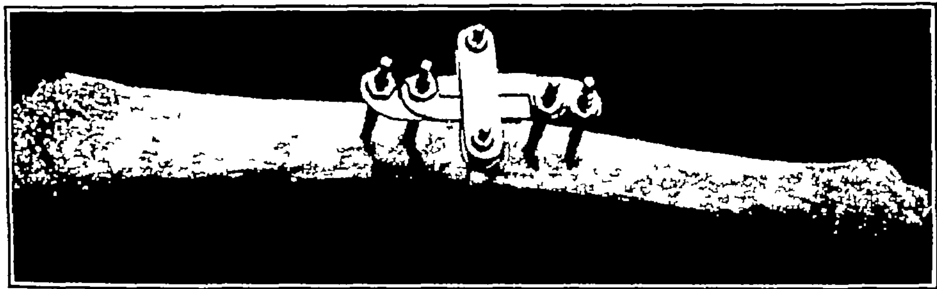


Fig 89 —Parkhill's "bone-clamp" in tibia, top view (Trans Am Surg Assn , 1897)

Starrett surface gauge Probably the simplest and least bulky of all types of apparatus is the present Roger Anderson model, designed by Fairbank and Stout, of the United States Army Dental Corps (Fig 90)

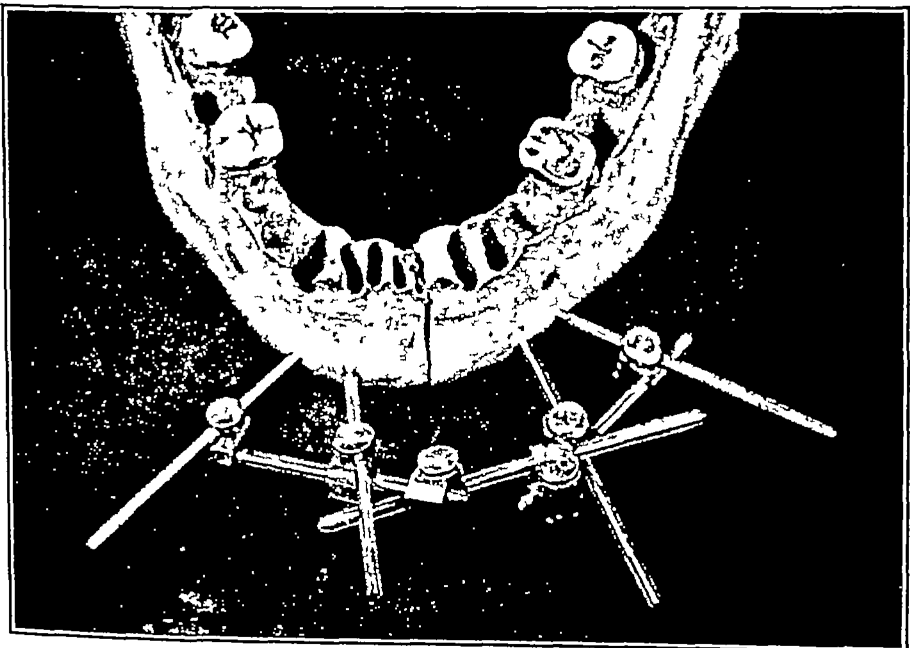


Fig 90 —Roger Anderson type apparatus as designed by Fairbank and Stout (Ivy and Curtis, Jour Oral Surg , 1 299, Oct 1943)

Indications for Use of Skeletal Fixation —Briefly put, the only indication for use of the method in the mandible is, in our opinion, the control of fragments where teeth are absent or do not afford adequate attachment for intra-oral appliances Under these circumstances, it is extremely valuable It should not replace the regular methods of intra-oral fixation when teeth are available, because the very exact occlusal relationships demanded when teeth are present cannot be assured by any methods other than those depending on the teeth for attachment In using the method for control of one edentulous fragment, skeletal fixation should be supplemented by dental fixation of the other fragment, if teeth are available (Figs 91 and 92)

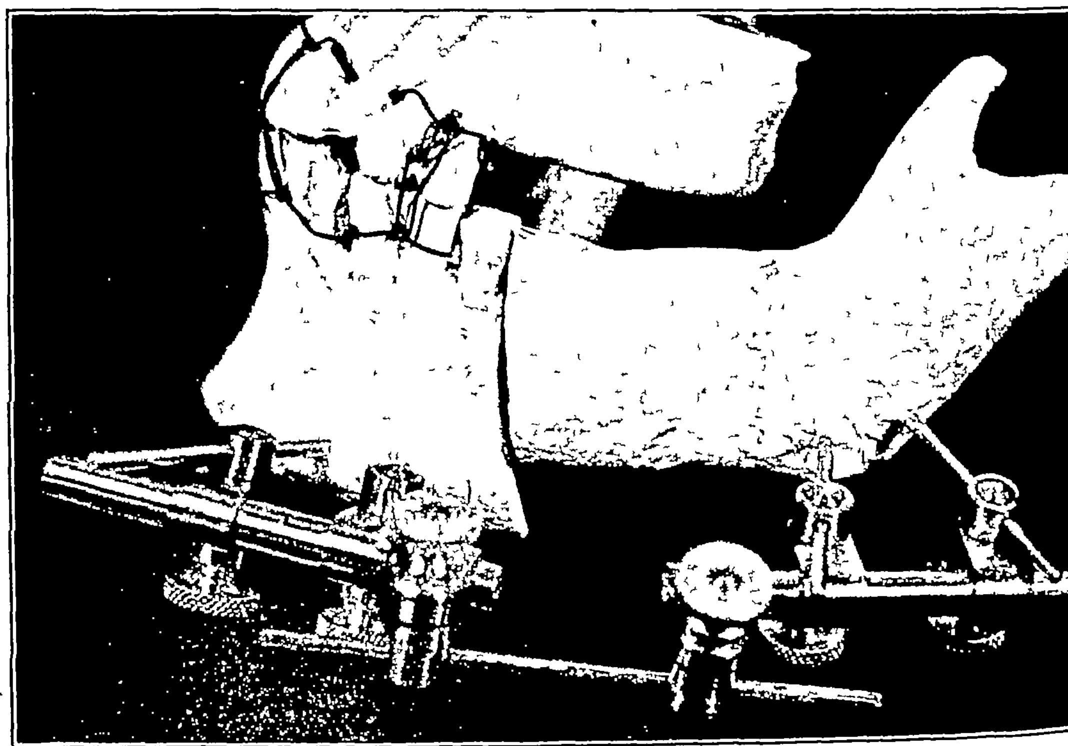


FIG 91 —Waldron's apparatus assembled in case of mandibular fracture with long edentulous posterior fragment, before reduction (Ivy and Curtis, Jour Oral Surg , 1, 299, Oct 1943)

Technique of Operation —Strict asepsis is necessary, and the outer operative field must not be contaminated by oral secretions or contact with fingers and instruments that have been in the mouth This is important The method, therefore, is not safe in the hands of those trained in intra-oral surgical technique The skin over the lower jaw is prepared just as for any other surgical operation

Stainless steel wire pins, 0 080-inch gauge, are ground to a triangular point, and threaded about one-third inch from the point upward The pin itself is used to make the hole in the bone, and is mounted in a hand-driven "egg-beater" type drill The pins should be placed as near the lower border of the mandible as possible, the two pins in each fragment forming an angle of about 45 to 60 degrees The pointed end of the pin,

mounted on the hand drill, pierces the skin and is passed in through the soft tissues until it reaches the outer plate of bone (Fig 93). It is then made to puncture the bone by slow rotation until the point engages the inner cortical plate. During insertion of the pins, an assistant, by the use of fingers and retractors in the mouth, holds the fragments steady, taking particular care not to contaminate the external operative field with his fingers It is inadvisable to drill the holes first and then try to insert the pins, because it is difficult to find the holes

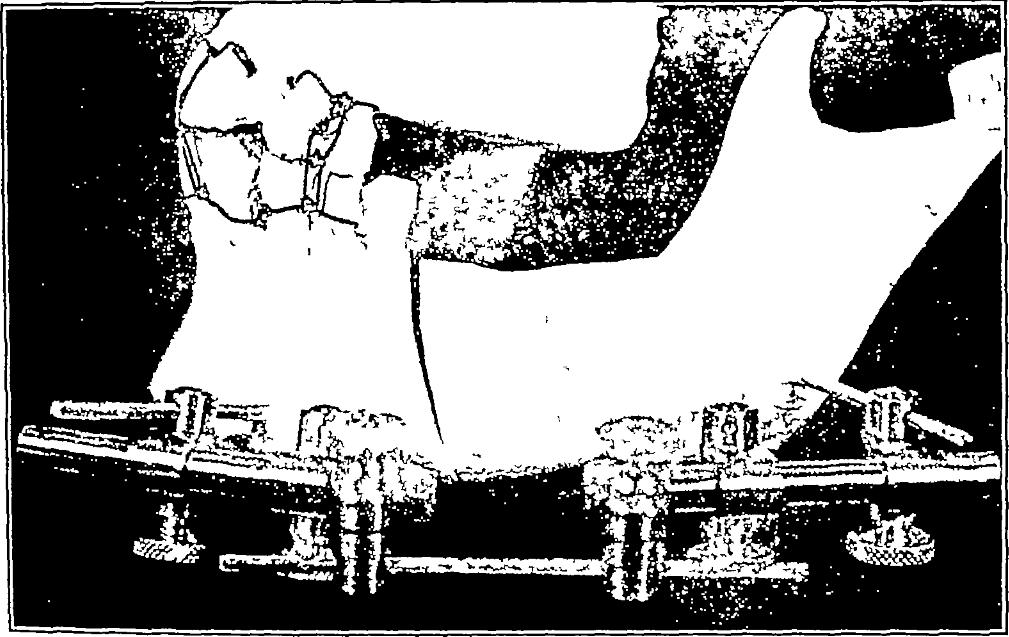


Fig 92 —Case shown in Figure 91, after reduction (Ivy and Curtis, Jour Oral Surg, 1, 299, Oct 1943)

The holes also should not be bored with an electrically driven instrument because of (1) difficulty in gauging the depth, and (2) the possibility of devitalizing surrounding bone by the heat In inserting pins about the angle of the mandible, care must be taken not to damage the facial artery or vein which traverse the overlying soft tissues in this region Greeley[13] has recently reported an arteriovenous aneurysm of these vessels due to puncture by one of the pins After the pins have been firmly seated in each fragment, the assistant holds the fragments in correct alignment while the operator adjusts the external connecting bar and tightens the clamps If strict asepsis has been followed, there is little irritation or seepage around the pins and they will remain firmly in the bone for the required period of about six weeks Usually they have to be unscrewed in order to be removed (Fig 167 on page 131 shows a case in which this method was used)

What promises to be an even better method of direct skeletal fixation than those just described is that employed by Penn and Brown[27] The apparatus consists of a clamp attached firmly to the lower border of each mandibular fragment, the bone being exposed through a skin incision, the

two clamps are connected after reduction by means of a rigid external bar The clamps insure a firm grip on the fragments, do not penetrate deeply into the bone, thus avoiding the chances of osteomyelitis and damage to internal bony structures which is always a possibility when intra-osseous pins are used



FIG 93 —Pin driven into bone through skin with hand power drill (Ivy and Curtis, Jour Oral Surg , 1, 299, Oct 1943)

Roentgen-ray Examination in Cases With Skeletal Fixation Appliances — Considerable difficulty has been encountered in obtaining satisfactory roentgen-ray views of the region of the fracture after application of the skeletal fixation, owing to interference by the apparatus with the adaptation of the patient's face to the surface of the cassette Dr L M Ennis, Professor of Roentgenology, School of Dentistry, University of Pennsylvania, has overcome this difficulty in a simple manner by placing a soft pad of cotton covered with gauze on the cassette The projecting parts of the fixation apparatus sink into the cotton pad, thus permitting the face to rest comfortably against the cassette (Figs. 94 and 95)

Fig 94 —Patient in position for radiographic examination of fractured area, fixation apparatus sinking into cotton pad on cassette



Fig 95 —Radiograph of same case, showing position of pins in bone and large defect in mandible due to gunshot wound

3 *Fracture of Edentulous or Almost Edentulous Mandible*—Many cases of fracture of the mandible where no teeth are present require no special fixation other than a head bandage, because exact alignment of fragments is not so important as in cases with teeth present since minor displacements can be compensated for in the artificial dentures With marked displace-

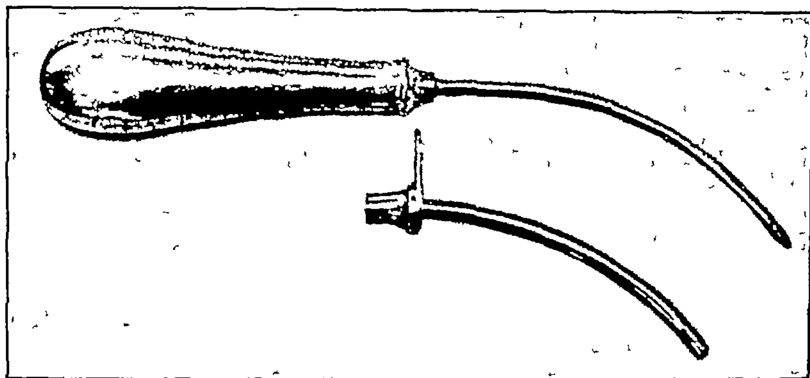


FIG 96—Antrum trocar and cannula, used in circumferential wiring

ment, however, positive fixation of some kind is desirable Good results are seldom obtained in recent fractures by wire sutures through the bone or metallic plates screwed into the bone across the fracture line Sufficient rigidity is seldom obtainable by these methods and infection around the wires and plates nearly always occurs



FIG 97—Circumferential wiring Trocar and cannula passed up through skin incision beneath jaw, on lingual side of bone

Circumferential Wiring—A much better plan in edentulous cases is circumferential wiring of the bone, originally employed by G V Black[12] This is also often very useful in conjunction with splints where the teeth are too few or insecure to afford attachment for wire ligatures In an edentulous case, a vulcanite splint is first made like a saddle, to cover the alveolar ridge on each side of the fracture. Or, if the patient has a full

lower vulcanite denture, as often happens, this may serve the purpose of a splint A small incision is made through the skin at the lower border of one of the fragments, and a small antrum trocar and cannula (Fig 96) are passed up through this incision close to the bone on the lingual side, until the mucous membrane of the mouth is pierced (Figs 97 and 98) The

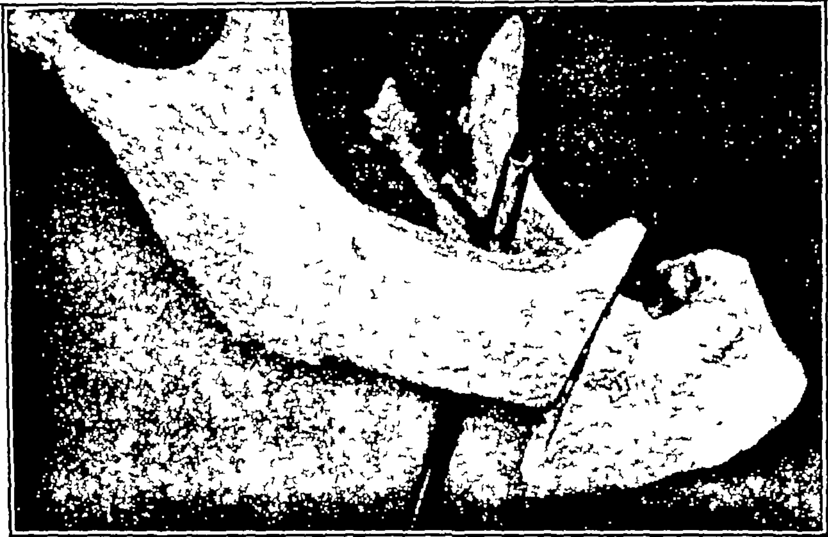


FIG 98 —Relation of trocar and bone in procedure shown in Figure 97

trocar is then removed, and one end of a No 24-gauge brass wire is threaded through the cannula from below (Figs 99 and 100) The cannula is withdrawn (Figs 101 and 102) and, by means of the trocar, is passed *downward*



FIG 99 —Wire passed up through cannula

from the mouth close to the bone, this time on the labial side, until its point emerges at the original skin opening (Figs 103 and 104) The othe end of the brass wire is then passed up through the cannula (Figs 105 an 106), and the cannula is withdrawn It is thus seen that the wire passe around the bone with its ends emerging in the mouth (Figs 107 and 108)

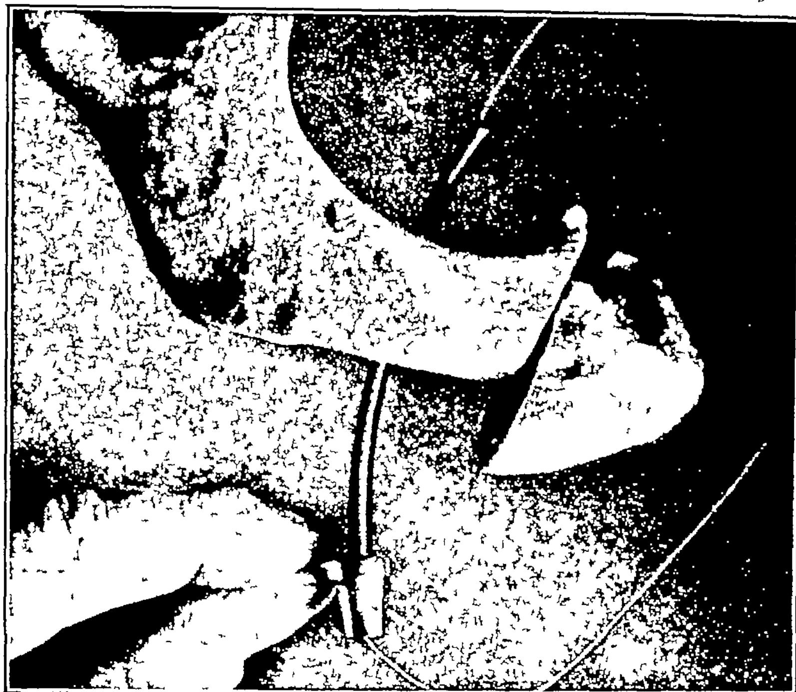


Fig 100 —Same as Figure 99.

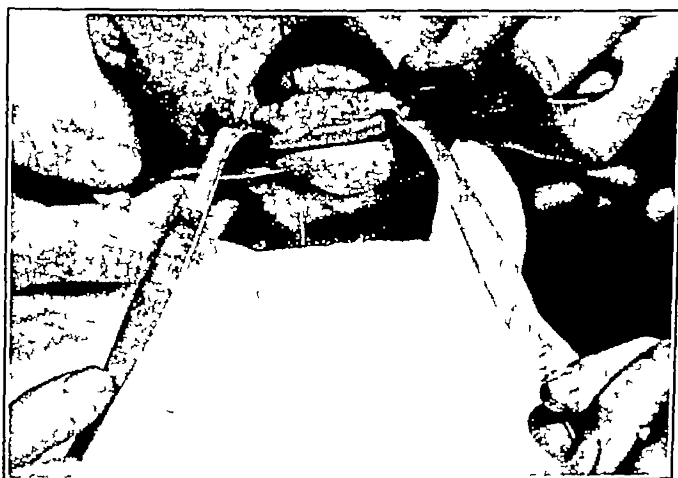


Fig 101 —Wire shown on lingual side of bone after withdrawal of cannula

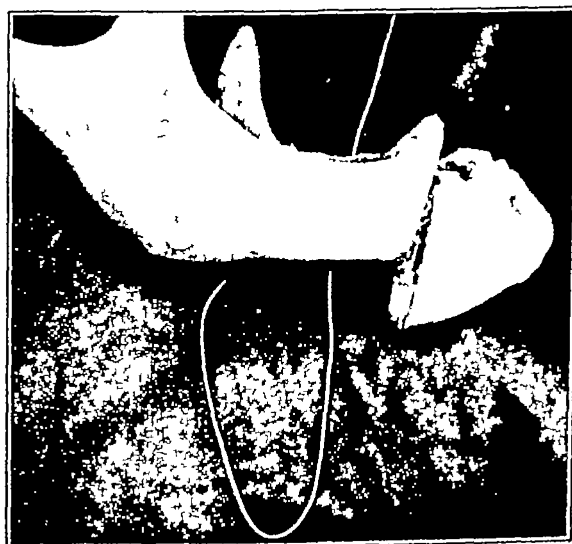


Fig 102 —Same as Figure 100

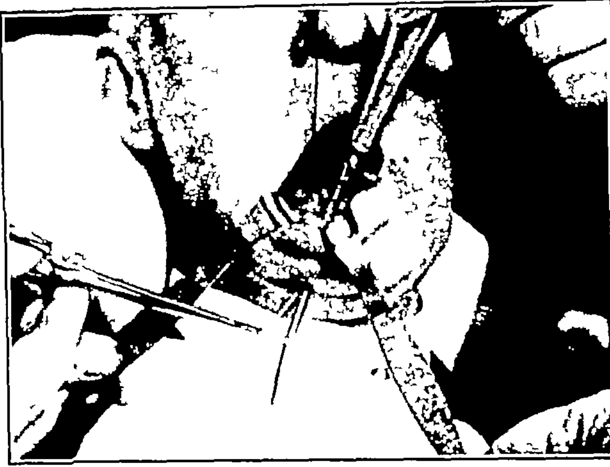


FIG 103 —Trocar passed down from mouth on labial side of bone to emerge through skin incision

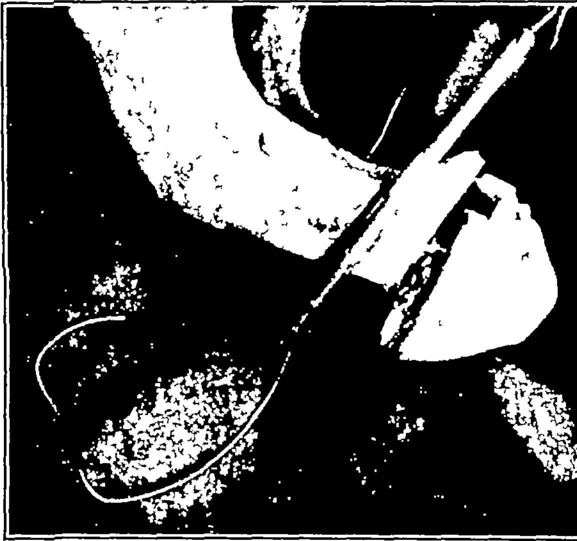


FIG 104 —Trocar passed down on labial side of bone



FIG 105 —Other end of wire passed up cannula into mouth on labial side of bone.



FIG 106 —Same as Figure 105



FIG 107 —Wire now around bone, with ends emerging in mouth

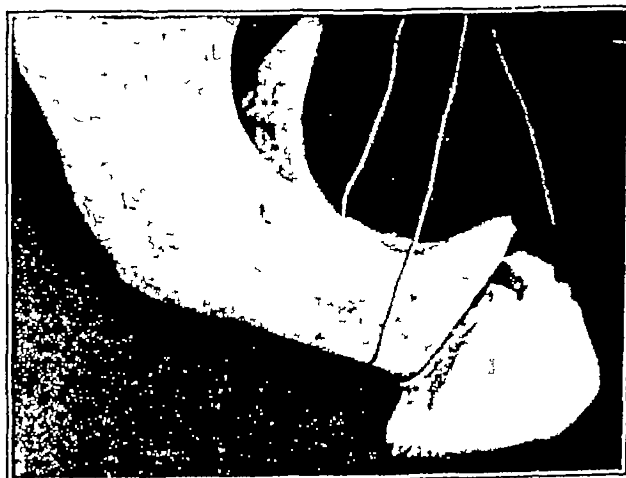


FIG 108 —Same as Figure 107

The ends of the wire are now twisted over the vulcanite splint or denture so that the bone fragment is drawn up snugly in contact with the splint (Figs 109 and 110). A similar wire is passed around the other bone fragment and twisted over the splint The procedure is shown diagram-



FIG 109 —Ends of circumferential wires twisted over artificial denture

matically in Figure 111 If it is not convenient to make a vulcanite splint, or a lower denture is not available, it is possible to make a splint by adapting a piece of soft metal plate over the entire alveolar ridge, then strengthening it by applying a cigarette-roll strip of modelling compound, heated

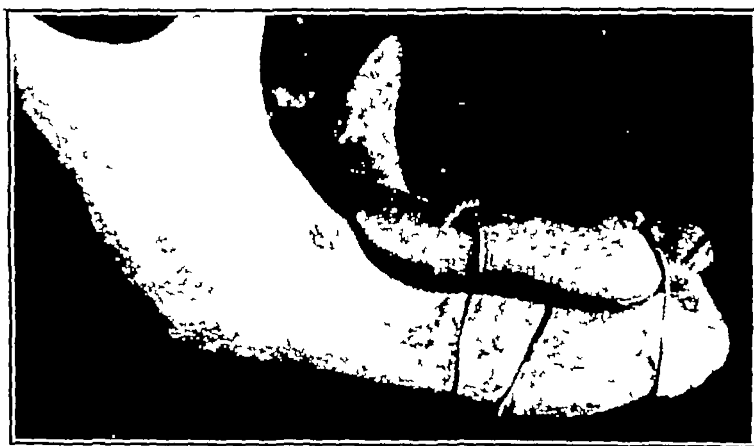


FIG 110 —Ends of circumferential wires twisted over splint

and softened over an open flame so that it will adhere to the convex surface of the metal (Fig 110) The circumferential wires are well tolerated, and may be retained for several weeks, the skin incisions frequently closing without suppuration (Figs 112 and 113) It is also possible to apply these wires around the mandible with a long, straight, 4-inch surgical needle—cutting edge—or with a pedicle needle The principle of application is the same as that employed with the trocar and cannula. Incidentally, when using the latter, we have found the small instrument used

for puncture and lavage of the maxillary sinus less bulky than the one illustrated in Figure 96 The circumferential wiring may be modified so that the two ends, instead of passing upward into the mouth, are made to emerge through the skin incision, the bone fragment being controlled by

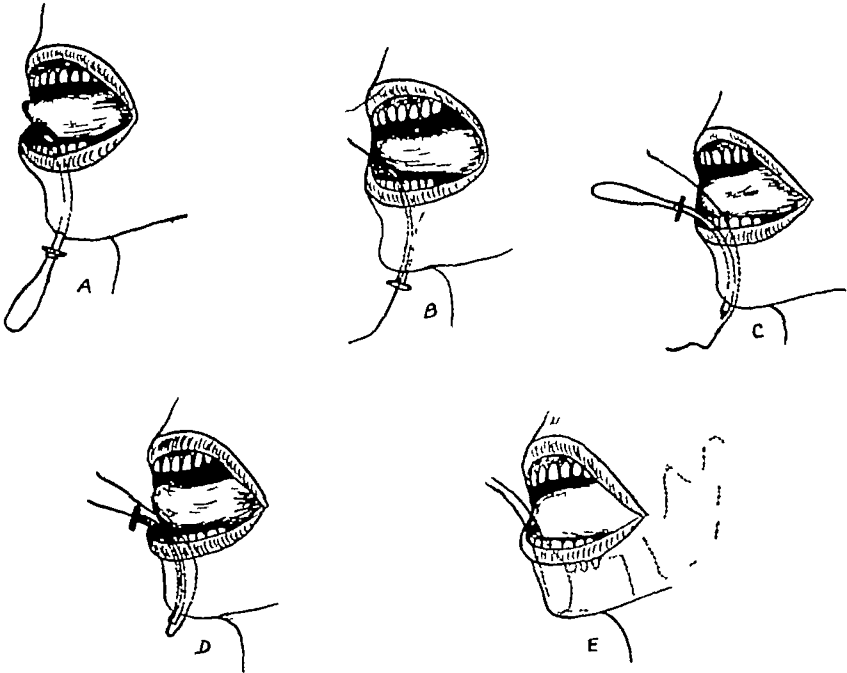


FIG 111 —*A*, Trocar passed through skin incision beneath the jaw into mouth on lingual side of bone, *B*, wire threaded through cannula on lingual side of bone, *C*, trocar passed down on outer side of bone, *D*, wire passed up cannula on outer side of bone, *E*, wire passing around bone after withdrawal of cannula, with ends in mouth ready to be twisted over top of splint



FIG 112 —Roentgenogram of almost edentulous mandible with double fracture before treatment

fixing the ends of the circumferential wire to a rigid bar passing downward from a plaster of Paris head cap A patient, completely edentulous in both jaws, had a bilateral fracture of the mandible with falling back of the tongue which interfered with deglutition and respiration Two circumferential wires were passed around the chin fragment, the ends emerging

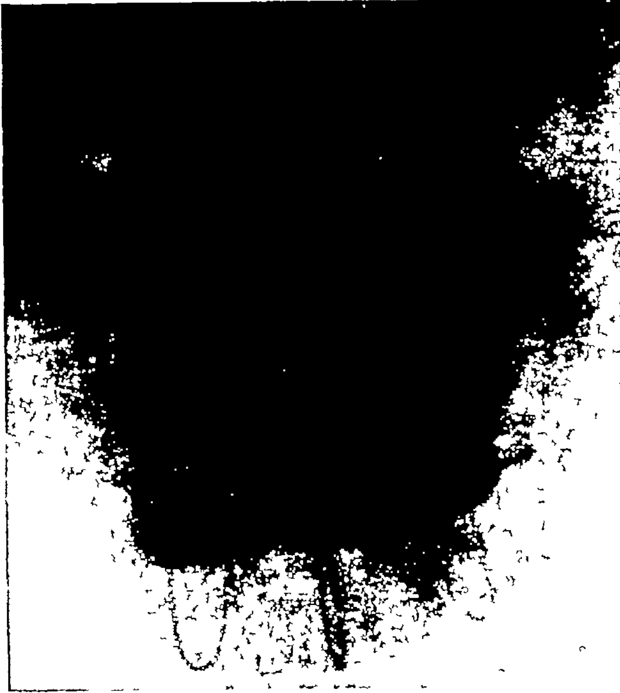


FIG 113 —Fixation of bilateral fracture of almost edentulous mandible by three circumferential wires tied over artificial denture (Ivy and Curtis Surg Clin North America, W B Saunders Company)

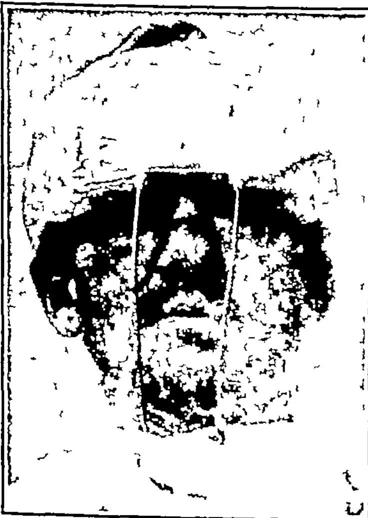


FIG 114 —Case of edentulous double fracture of mandible with fixation of symphysis fragment in forward position by circumferential wires and head cap



FIG 115 —Profile view of case shown in Figure 114 (Ivy and Curtis Surg Clin North America, W B Saunders Company)

through skin incisions at its lower border and fastened to coat hanger-wire bars extending downward in front of the face from a plaster head cap (Figs 114 and 115) By this means the chin was held in a forward position, relieving the breathing and swallowing, and allowed union of the fractures in satisfactory position Figures 116 and 117 show the use of circumferential wires in conjunction with an arch bar on the teeth, where the teeth alone do not afford sufficiently firm attachment One case of oblique fracture in an edentulous mouth has been successfully treated by a wire passed subcutaneously and submucously around the bone so as to



FIG 116 —Radiograph of the right side of the mandible showing two fractures on the same side

embrace the overlapping of the fragments No splint was used in conjunction with the wire and firm union occurred without suppuration, even though the oral mucous membrane was slightly torn in introducing the wire through a skin incision beneath the jaw The wound healed perfectly and the wire was still in place some months after the operation

4 *Fracture of Mandible With Edentulous Upper Jaw* —If the fracture is in the line of the teeth, with little displacement, a single half-round arch wire embracing the lower teeth may give sufficient fixation. But if there is a great tendency to displacement, or if the fracture is posterior to the last existing tooth, support must be obtained elsewhere If the patient has an upper artificial denture, this may be made to serve for attachment of wires from the lower teeth by drilling holes through it Or circumferential wiring of the fragments may here prove useful In one

case of fracture through the neck of the condyle, with lateral deviation of the jaw, correction was brought about by elastic traction from a plaster head cap to an arch wire fastened to the anterior teeth (Fig 118)

Fig 117 —Radiograph of the left side of the same case, showing circumferential wires supporting mandibular fragments, the ends being attached to arch bars on the upper teeth



Fig 118 —Lateral traction from head cap to correct deviation due to fracture throu neck of left condyle Upper jaw edentulous (Ivy and Curtis Surg Clin North Ameri W B Saunders Company)

5 *Comminuted Fracture of the Symphysis, With Loss of Incisor Teeth* These are among the most difficult mandibular fractures to maintain position There is a strong pull of the mylohoid muscles toward

median line, resulting in a marked narrowing of the lower jaw so that the gap normally occupied by the incisor teeth is closed and the line of the lower teeth farther back on each side is within that of the upper teeth (Fig 24) If union occurs in this position the function of mastication by the remaining sound teeth is crippled and cannot be restored by artificial dentures This tendency to contracture persists sometimes for several months, and if great vigilance is not observed will resist efforts to overcome it The ordinary eyelet method of wiring, even though the remaining upper and lower teeth are good, usually gives insufficient purchase to maintain correct position If seen early, when the two sides are easily reducible to their full width, fixation by upper and lower half-round arches may suffice, but it is always wise, and usually necessary to maintain the space by using a rigid crib of half-round arch wire, which also serves as a mandibular arch bar

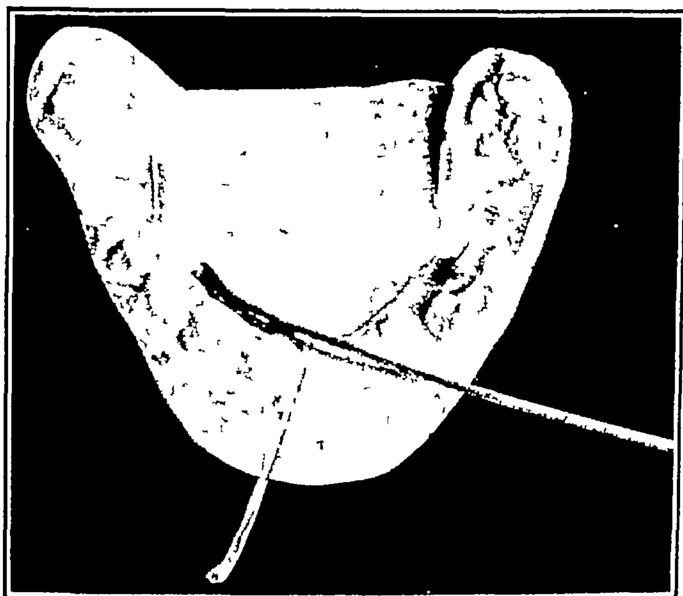


Fig 119

A 6-inch piece is used for this purpose We usually have some trismus in these cases so we must do most of the work through the space where the teeth were lost, with the mouth nearly closed At a point 2 inches from either end the wire is bent upon itself, round to round, and the bend closely compressed with parallel pliers Neither this, nor the second tight bend, which is to be made, must be unbent in the slightest degree or the wire will break at that point The two approximate wires are firmly grasped by the parallel pliers at a distance from the bend equal to the width of the two teeth immediately to the right of the space and the 2-inch piece of the double wire bent away from the longer piece at right angles The ½ inch or so of remaining parallel wire from the bend to the right angulation is then made to fit the lingual surfaces of the two teeth mentioned above with contouring pliers (Fig 119) The longer piece of wire is now roughly bent to conform with the dental arch and is then

tightly bent upon itself, round to round, at a point estimated to take in the two teeth immediately to the left of the space with the two fragments properly spaced in relation to the upper jaw (Fig 120) The bar is made

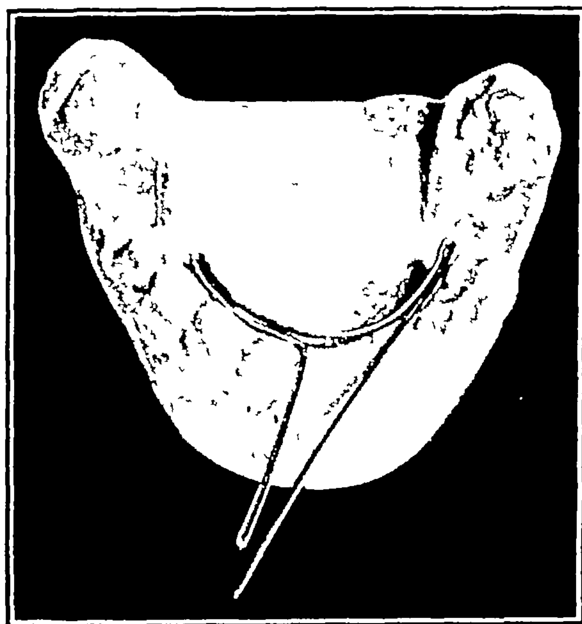


Fig 120

to accurately fit the lingual surfaces of the teeth, as on the right side, and the short remaining piece of the wire is bent forward at right angles (as on the right side) so that the distance between these two right angle bends equals that between the mesial surfaces of the teeth adjacent to the space

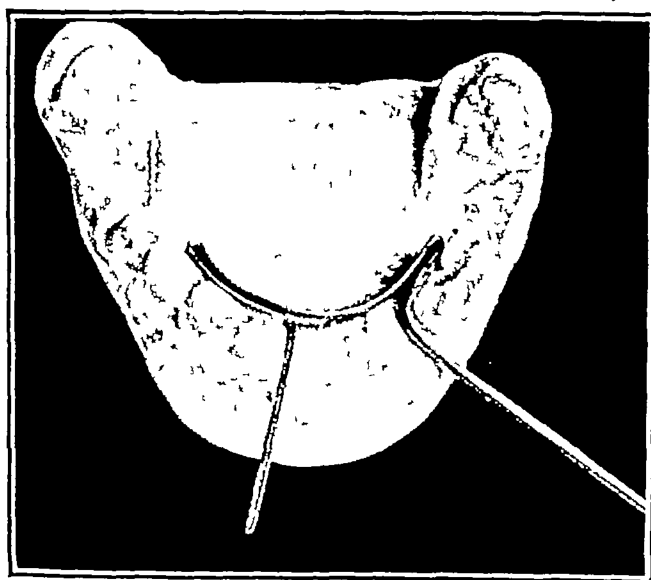


Fig 121

with the fragments properly spaced (Fig 121) There remains but to adapt the two short portions of the bar to the buccal and labial surfaces of the teeth after bending them around the teeth at either side of the space

and to fix the completed crib by wire ligatures about the teeth (Fig 122) We thus have a simple and efficient means of maintaining the proper width of the lower arch, made of one piece of half round wire in less time than it takes to write about it The crib is attached to a bar, or eyelet loops

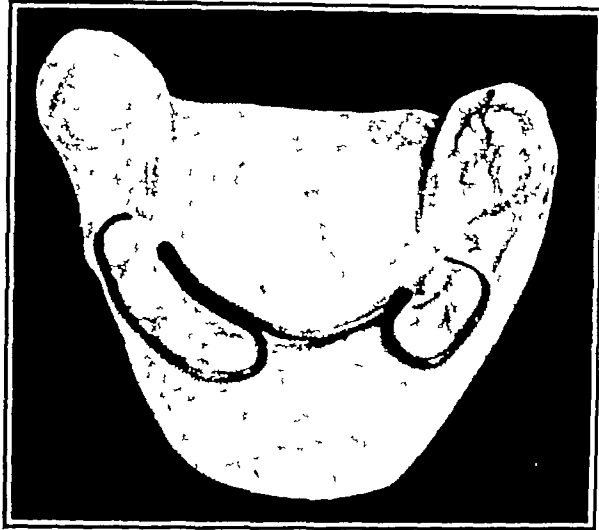


FIG 122

on the upper teeth by connecting wires and the mandible immobilized for about four weeks, depending on the gap in the bone at the symphysis, after which the mandible is allowed to function normally with the crib remaining in place for several weeks until there is good union An artificial denture should be made and inserted as soon as possible after the crib is discarded.

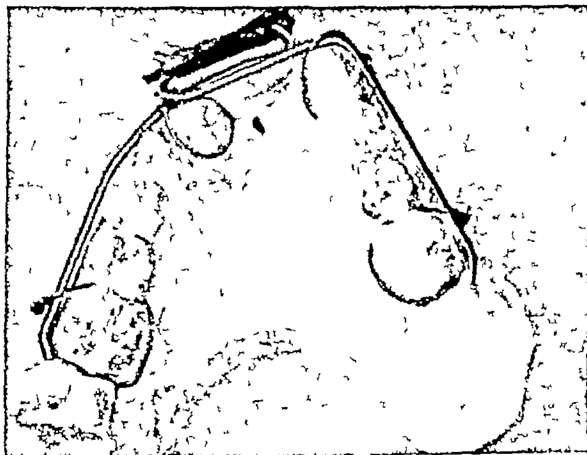


FIG 123 —Separation of fragments by elastic traction in comminuted fracture of symphysis of mandible (Ivy and Curtis Surg Clin North America, W B Saunders Company)

If seen late, and there is narrowing of the arch with but incomplete union, some means of obtaining the full width of the lower arch should be attempted A satisfactory and simple way of attaining this is a modification of that of Schellhorn [31] Separate arch wires are applied to the teeth of

each half of the mandible The anterior ends of the two arches are left long enough to overlap each other across the gap Each end is bent to form a hook, and a small rubber band around the two hooked ends exerts force on each fragment away from the median line (Figs 123 and 124)



FIG 124 —Appliance in mouth of patient Same as shown in Figure 123 (Ivy and Curtis Surg Clin North America, W B Saunders Company)

The lower teeth are also connected with the upper by wire ligatures passed around the arches After full reduction has been obtained the space can be maintained by replacing the expansion apparatus with a rigid crib (Fig 125) If the space is narrow and seen so late that there is bony

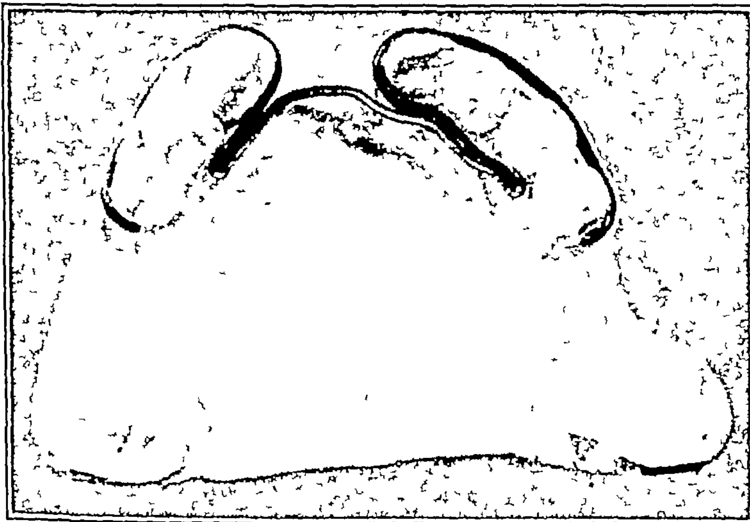


FIG 125 —Rigid crib made of half-round wire to maintain separation

union, the jaw bone should be separated with a Gigli saw and treated as a fresh fracture If the gap is too wide for automatic union, a bone graft may be inserted

6 *Fracture of the Mandible Complicated by Fracture of Maxilla* —The upper jaw fragments are fixed according to the principles described in

Chapter V. If sufficient stability can be obtained, the ordinary means of fixation by attachments to the teeth are employed for the lower jaw. If the upper teeth are not available for attachment of the lower, or if the lower teeth are inadequate, then control of the mandibular fragments must be obtained by circumferential wires attached to a plaster head cap (For description of case in this class see p 91)

Time Required for Union.—This depends on the character of the fracture, the number of fractures, and the reparative effort of the individual In single fractures, without suppuration and no appreciable loss of bone, fairly good union may occur in three weeks, although as a rule at least five weeks of fixation are required Where much comminution is present or where the case is complicated by infection and osteomyelitis, a much longer time for repair is required In 100 cases recently reported,[17] the average number of days that fixation was maintained was thirty-one and a half The shortest time was fourteen days in a single fracture wired within twenty-four hours after the injury, the longest seventy-five days in a double fracture wired more than a month after injury. In another series, calculated from date of injury to end of treatment, the average time for firm union was forty-eight days.

FRACTURES IN CHILDREN

Fractures of the mandible in young children sometimes present difficulties in fixation because the deciduous teeth may not be sufficiently strong or retentive to afford proper attachment for wires Under these conditions methods employed in edentulous cases, such as circumferential bone wiring, plaster head caps, etc , may have to be employed

The following case illustrates the necessity of often resorting to the construction of some ingenious device for treating these juvenile fractures

R F , a boy, aged six years, had a portion of the left body of the mandible blown away by the explosion of a 1 pound shell, leaving a considerable gap in the bone from the left deciduous canine to the first permanent molar The maxillary teeth, mostly deciduous and small, could not be used for any type of attachment. The problem resolved itself, therefore, into one of maintaining the proper relation of the mandibular fragments Bars could be attached to the anterior fragment and remain attached, but it was impossible to fix the posterior end of any type of rigid appliance to the partially erupted molar in the posterior fragment, either by wiring or cementing Finally one of our orthodontist friends fastened a bar to the anterior fragment with a ball at one end which fitted into a socket soldered to an orthodontic band cemented to the molar This maintained the necessary space between the fragments to forestall a narrowing of the arch with subsequent deformity, and, at the same time permitted some inevitable motion between the fragments The gap gradually filled in with new bone

Another case in a child where the teeth could not be used for fixation is illustrated by Figures 138, 139 and 140.

SUMMARY OF METHODS OF FIXATION OF FRACTURES OF MANDIBLE

Type of Fracture	*Method of Fixation*
1 In any part of bone with sufficient occluding mandibular and maxillary teeth	Wiring teeth in occlusion by eyelet method (p 50)
2. In any part of bone with insufficient teeth for eyelet method	Wiring teeth in occlusion by half-round wire arches (p 56)
3 In any part of bone with immediate reduction not possible	Eyelet method or half-round wire arches and gradual reduction by intermaxillary elastic bands (p 57)
4 Neck of condyle	Wiring teeth in occlusion by eyelet method or half-round wire arches, and interposition of gutta percha block between occlusal surfaces of molar teeth on side of fracture (p 66)
5 Molar or premolar region with long edentulous posterior fragment	Eyelet method or half-round wire arch for intermaxillary fixation of teeth in long fragment Wire from angle on short fragment to hook on plaster head cap (p 68) Skeletal fixation (p 77)
6 Molar or premolar region with teeth in posterior fragment but no opposing maxillary molar teeth	Vulcanite denture for maxilla with bite block to represent missing molar teeth Wiring mandibular teeth in occlusion (p 76)
7 Edentulous or almost edentulous mandible	Circumferential wiring of fragment in connection with artificial denture or saddle (p 84)
8 Teeth in mandible but maxilla edentulous	If teeth sufficient, half-round arch wire on mandibular teeth alone If not sufficient teeth or fracture behind teeth, arch wire or circumferential wire to head cap (p 92)
9 Comminution of symphysis with loss of incisor teeth	Crib of half-round arch wire If gradual expansion necessary, arch wires and elastic band (p 93)
10 Fracture of maxilla as well as mandible	Circumferential wiring and head cap often necessary (p 97)
11 Children, where teeth are inadequate for attachment	Circumferential wiring and head cap

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CHAPTER IV

COMPLICATIONS OF FRACTURES OF THE MANDIBLE

HEMORRHAGE

Bleeding of any severity is an unusual complication of ordinary fractures of the mandible Rupture of the inferior dental artery is common, but the severed vessel ends generally retract quickly in the bony canal, with spontaneous cessation of the bleeding It is only rarely that prolonged intra-oral hemorrhage occurs from the bone through a laceration of the gum tissues

Treatment.—Hemorrhage from the seat of fracture usually ceases spontaneously after the parts have been put at rest by dental fixation Occasionally, secondary oozing into the mouth from the wound at the fracture line may be observed If severe, the jaws should be separated by cutting the tie wires, any clots cleared out, and a pad of gauze placed over the seat of hemorrhage, pressure being maintained by again connecting the upper and lower teeth with the wires After twenty-four hours the gauze should either be changed, or if the hemorrhage has ceased, it may be discontinued Mechanical pressure is far more efficacious than application of chemical agents to promote blood coagulation A last resort would be ligation of the external carotid artery, though we have never seen hemorrhage in this connection which could not be controlled by less severe measures

LACERATION AND CONTUSION OF SOFT TISSUES

Extensive laceration and contusion of the soft tissues with large open wounds through the skin occasionally complicate fractures of the mandible, especially those resulting from automobile accidents and gunshot injuries

Treatment.—The wounds should be thoroughly cleansed, and sutured after fixation of the fracture, provision being made for dependent drainage if the wound is beneath the lower border of the mandible The routine prophylactic injection of anti-tetanic serum is advisable

RESPIRATORY DIFFICULTY

Certain bilateral fractures of the mandible, especially those due to gunshot wounds, are accompanied by partial obstruction of the respiratory passages due to loss of support of the tongue at its anterior attachments There is thus a mechanical closure of the glottis due to the tongue falling back Respiratory embarrassment may also be caused by pressure from

swelling due to the extravasation of blood and serum in the tissues of the floor of the mouth These factors also produce difficulty in swallowing

Treatment.—Difficult respiration and swallowing caused by backward displacement of the chin fragment is relieved by bringing the fragment forward into correct position and holding it there Insertion of a curved metal airway may be found useful in some cases Swelling due to extravasation may be reduced by an ice collar to the neck, or by providing drainage beneath the lower border of the jaw Tracheotomy rarely becomes necessary The patient may have to be fed liquids through a funnel and tube passing over the tongue to the pharynx, or at times even through the nose.

INFECTION

The majority of fractures involving the body of the mandible are compound through a break in the oral mucous membrane, affording a means of ingress for the microorganisms always present in the mouth Consequently, infection from this source is frequent Another source of infection may be microorganisms already present in the bone about the apices of pulpless teeth The possibility of infection is increased by excessive trauma to the bone, producing wide separation of the fragments, comminution, crushing and devitalization of surrounding soft tissues An unhealthy condition of the mouth increases the virulence of the microorganisms, so that here we should expect infection more frequently following fracture than in persons who practise oral cleanliness The general physical condition of the patient, of course, also has a great influence on the incidence of infection A tooth root exposed in the line of fracture compound into the mouth often acts as a necrotic foreign body and thus a secondary source of infection Lack of early fixation of the fracture predisposes to infection The microorganisms responsible for the infection are commonly the pyogenic staphylococci and streptococci. With these are frequently associated the colon bacillus and Vincent's organisms

Symptoms and Clinical Course of Infection.—The pain and swelling directly due to the trauma usually subside in a few days Infection about the fracture is heralded by a reappearance or an increase in the swelling and the pain The skin at the site of the fracture becomes red, indurated and tender, followed by softening and fluctuation as pus approaches the surface Inside the mouth also, the gum about the fracture usually presents tumefaction, and pus may be discharged spontaneously around the teeth The temperature is usually elevated Prolonged suppuration, either through the gum or through an opening in the skin usually means that there is a definite osteomyelitic focus in the bone fragments. This is favored by the presence of devitalized tooth roots Spreading of the osteomyelitis is characterized by suppuration and loosening of previously healthy teeth not immediately in the fracture line Sequestrum formation is frequent In a series of 100 fractures of the mandible, 19 developed suppurative infection requiring drainage by incision In 9 cases, sequestrum formation occurred

Treatment.—Some writers advocate a routine prophylactic skin incision down to the lower border of the mandible at the site of fracture, and insertion of a strip of rubber tissue to forestall infection We do not feel that this is necessary in all cases But as soon as the presence of pus is evident, then this should be given an opportunity to escape through an adequate incision at the most dependent point Late infection may occur around a tooth in or near the fracture line which at the time of fixation was apparently not involved, or which was purposely allowed to remain on account of its importance in maintaining fragments in position In such a case the connecting wires between the upper and lower teeth should be cut and the tooth extracted If possible, it is best to avoid general anesthesia for the extraction, on account of the danger of straining the lower jaw and getting the fragments out of position After the extraction, the ligature wires on the teeth can usually be replaced immediately



Fig 126 —Roentgenogram of fracture at angle of mandible, showing sequestrum

With adequate incision and drainage and removal of infected teeth, many times the suppuration will clear up promptly If the suppuration continues, this is an indication of bone infection and necrosis (Fig 126) In this case, waiting for the separation of sequestra by natural processes brings about better end results than attempting radical removal of the diseased bone By attending to proper drainage and cleansing by irrigation and then removing sequestra as they form, it is possible to have the lost bone almost completely replaced by new bone, with avoidance of non-union On the other hand, if the diseased bone is resected before complete sequestration, there is generally great interference with regeneration, resulting in non-union We have frequently seen complete consolidation of the fracture long before the bone infection has cleared up In all cases of prolonged bone suppuration, after local factors have been accounted for,

careful search should be made for systemic complications, such as syphilis and tuberculosis, and if found, treatment given to eliminate these

TRISMUS

Nearly all cases of fracture of the mandible, especially those near the angle, after prolonged fixation with the teeth in occlusion, are followed by

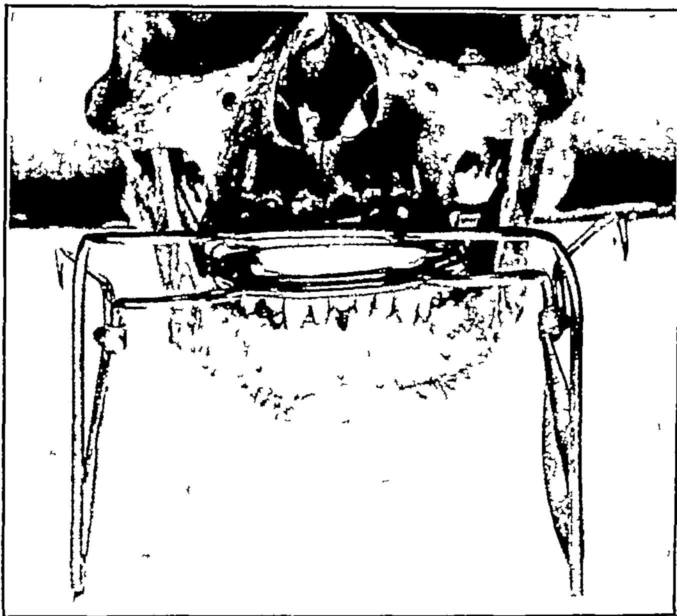


FIG 127 —Author's trismus apparatus—applied to skull

a period of limited opening of the jaws Usually this requires no treatment, as the normal movement of the mandible gradually returns with efforts at mastication Occasionally the return of normal movement is

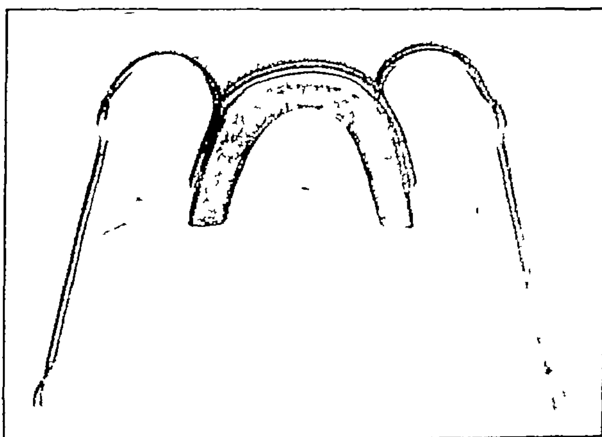


FIG 128 —Trismus apparatus—details of lower tray

retarded on account of a certain amount of fibrosis or atrophy of the muscles These cases are greatly benefited by regular application of a

mild interdental elastic force to separate the upper and lower jaws Figures 127, 128 and 129 show an apparatus which we have found very useful for this purpose[6] It is made in three sizes, ready for immediate use where there is an initial opening between the anterior teeth of 1 cm The two parts of the appliance consist of flat metal trays passing between the occlusal surfaces of the maxillary and mandibular teeth To the outer sides of each tray are soldered heavy bars which pass out of the mouth and curve backward over the cheeks The bar attached to the upper tray on each side turns down at a right angle about opposite the premolar region and ends in a hook about 3 inches lower down The bar attached to the lower tray passes directly backward horizontally and is provided with a hook at a point opposite the downward turn of the upper wire The dilating force is a heavy elastic band placed between these hooks on each side This application of dilating force in the manner described is original

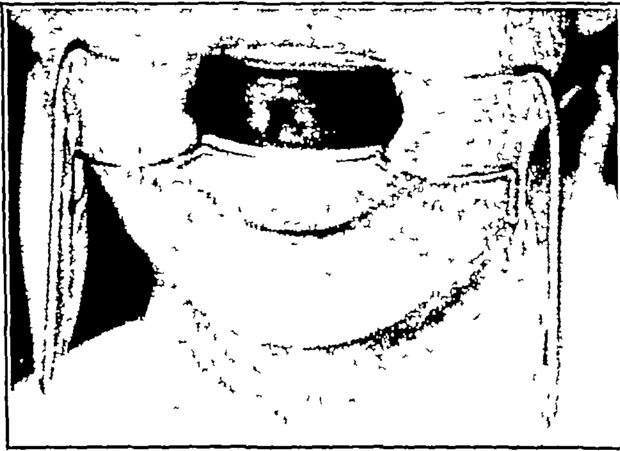


Fig 129 —Trismus apparatus in use.

with Darcissac[2] Darcissac, however, made individual apparatus from impressions of each case, casting metal caps to fit the teeth The advantage claimed for the present appliance is that it is ready for immediate use in any case with not less than 1 cm of separation, without the necessity of impression taking The elastics produce a constant counteraction to the powerful elevator muscles of the mandible, which at the same time are permitted to function, the upper and lower jaws being at no time fixed Lateral movements as well as opening and closing are possible Where additional stability is desirable the trays may be filled with a little softened impression compound before insertion, to receive the imprint of the teeth This compound can be renewed from time to time The dilating force can be regulated by the size and tension of the elastic bands The apparatus can be inserted by the patient or some one in the house with him It should be worn for a period of fifteen or twenty minutes three or four times a day, and usually produces sufficient results in fracture cases within a week or ten days

MALUNION

It is surprising how many fractures of the mandible unite in good position in spite of lack of artificial fixation or with the mere application of a head bandage This is because in such cases there is practically no displacement in the beginning and the fragments are self-retentive This fact, however, does not excuse the omission of firm fixation in all cases except linear fractures where no movement can be detected Far too many bad results in the form of malunion with malocclusion of the teeth and interference with function are seen as the result of neglect of this important principle

Treatment —The majority of cases of malunion can and should be corrected by operative measures If the case is seen before consolidation is complete, *it may be possible by gradual elastic traction to reduce the*



Fig 130 —Osteotomy of mandible Trocar passed up through small skin incision

fragments to normal position If firm bony union in bad position has occurred, osteotomy through the original fracture line, followed by reduction and fixation in correct position, is indicated The simplest cases are those in which there has been no loss of bony tissue from necrosis Where considerable bone has been lost, after osteotomy and replacement, a second operation to supply new bone may be necessary before proper continuity will be restored

Technique of Osteotomy —A small incision through the skin, not more than ½ inch long, is made to the lower border of the mandible at the site of the fracture A curved antrum trocar with cannula (Fig 96) is introduced through the incision close to the bone on the lingual side until the mucous membrane of the mouth is pierced (Fig 130) The trocar is then

withdrawn, and a Gigli's wire saw is passed through the cannula until one end protrudes into the mouth (Fig. 131). After removal of the cannula, the mandible can be readily sectioned through the old fracture line with



FIG 131 —Osteotomy of mandible Gigli saw passed up through cannula on inner side of bone

the Gigli saw (Fig 132) The skin incision is closed with a fine dermal suture, without drainage, and usually heals by first intention, leaving practically no visible scar If no bone has been lost from necrosis, it now



FIG 132 —Osteotomy of mandible Gigli saw ready to cut through old fracture line

becomes possible to reduce the fragments and treat the case by intermaxillary fixation as in a recent fracture Figures 133 and 134 illustrate a case of malunion treated by osteotomy



FIG 133 —Double fracture of mandible with union in malocclusion



FIG 134 —Same case as in Figure 133, after osteotomy and fixation in good position

DELAYED UNION

Union may be retarded by lack of approximation or by lack of fixation of the fragments, by the interposition of muscle fibers, detached bone fragments, teeth or a foreign body, by local infection, or some fault in the vital reparative effort Syphilis, tuberculosis, or any general debilitating disease may be responsible for delayed union, but at times no cause can be found While local infection usually retards union, on the other hand, cases are frequently seen, complicated by osteomyelitis and sequestrum formation, in which union of the fracture occurs long before the bone infection clears up

NON-UNION

Non-union is rare in cases of fracture of the mandible encountered in civil practice, although, with the increasing number of automobile accidents, more cases are being seen with extensive loss of bone from osteomyelitis and necrosis, or extreme comminution The commonest causes of failure of union after fracture are suppuration in the line of fracture due to retention of denuded roots of teeth, lack of early reduction of extremely displaced fragments, extensive loss of bone caused by the severity of the injury and subsequent osteomyelitis and necrosis Attention has already been called to the possibility of systemic factors, such as syphilis and tuberculosis, which should not be overlooked About 11 per cent of gunshot fractures of the mandible result in healing of the parts with non-union of the fragments [5]

Treatment —Non-union may occur with the parts in practically normal position, the fragments being separated by only a small amount of fibrous tissue Here it may be possible to obtain good union by freshening the ends of the bone and holding them in contact without materially disturbing the dental occlusion

On the other hand, when there has been considerable loss of bone, ranging from 1 to 5 or 6 cm , this gap should not be obliterated by bringing the bone ends together, as too much disturbance of the occlusion will result, and there may also be an accentuation of the external deformity Here, any fibrous adhesions should be cut at a preliminary operation, the fragments reduced to as near normal position as possible, and held there by suitable methods of intermaxillary fixation until complete healing has occurred Then the gap representing the bone loss should be filled by a bone graft, restoring the continuity and original length of the bone In view of the generally excellent results which are obtained by this procedure, it is surprising to note the occasional appearance of writings promoting the opposite view, *viz* , that it is better to assure union in these cases as soon as possible, at the expense of occlusion and external appearance, by bringing the bone ends in contact with no attempt to restore the original length of the bone

Successful bone grafting depends upon adherence to certain underlying principles, among which are waiting until the elimination of all sepsis in the field of operation has taken place, proper preliminary fixation of fragments by intra-oral or extra-oral methods already described, the employment of rigid aseptic technique, and the avoidance of infection by opening into the buccal cavity at operation

METHODS AND TYPES OF BONE GRAFTS

In many of the World War cases, restoration of continuity was brought about by employing a *pedicled graft taken from the mandible itself* This method was first described by Bardenheuer in 1893,[10] and was popularized by Cole, of London [1] We have not used this method recently because we

found that it produces undue distortion of the soft tissues of the floor of the mouth and neck, and is not suitable for large losses of bone substance, especially in the region of the angle and ascending ramus of the mandible. We consider, also, that the cortex of the tibia is unsuitable as a source of bone graft for the mandible, because of its extreme density and consequent resistance to penetration of new blood vessels in the process of consolidation Also, fracture of the tibia after removal of a thick graft is not unknown During the past nineteen years, we have limited ourselves to two methods, each having definite indications

1 **Osteoperiosteal Method of Delagénière.**[3]—The osteoperiosteal graft contains all of the elements necessary for osteogenesis, is flexible, and is easily adjustable to the size and shape of the defect The technique of removal and insertion is simpler than that of any of the other methods It causes no disability in the leg It requires longer to obtain complete consolidation than by other methods, and no dependence, of course, can be placed on the rigidity of the graft itself for maintenance of the mandibular fragments While this form of graft can be used for losses of substance of the mandible of almost any extent and any position, we reserve it for defects of 2 cm or less, and in cases where the external contour of the face shows little or no deficiency

Technique of Osteoperiosteal Method—The procedure is divided into three stages (*a*) Preparation of the mandibular site, (*b*) removal of the graft, (*c*) application of the graft to the mandibular defect

(*a*) The patient is etherized without disturbing the fixation apparatus on the bone fragments The first step is exposure and preparation of the ends of the mandibular fragments This is done before removing the graft from the tibia in order that the size of graft required may be determined and also on account of the possibility of opening into the mouth while preparing the bed for the graft, an accident which would render useless the application of the graft at this time A skin incision with convexity downward is made over the region of the bony defect, and the skin flap is turned upward A second flap, consisting of deeper tissues, is then turned up Extreme care is taken to avoid opening into the buccal cavity Scar tissue is removed to expose thoroughly the ends of the bone fragments A pocket is prepared around the end of each fragment by stripping away the periosteum and soft tissues from its inner, outer and under surfaces for a distance of about 1 cm (Fig 135) The exposed bone is freshened by trimming with rongeur forceps Bleeding is controlled as completely as possible

(*b*) The antero-internal surface of the tibia is exposed by a longitudinal incision through the skin down to the periosteum The graft to be removed, usually about 10 cm long by 2 cm wide, is next outlined with the knife through the periosteum to the bone With a broad, thin chisel, held perpendicular to the bone, the tracing made by the knife is accentuated, the edge of the chisel penetrating the bone to a depth of 1 or 2 mm. The chisel is then held almost horizontally, with bevel toward the bone,

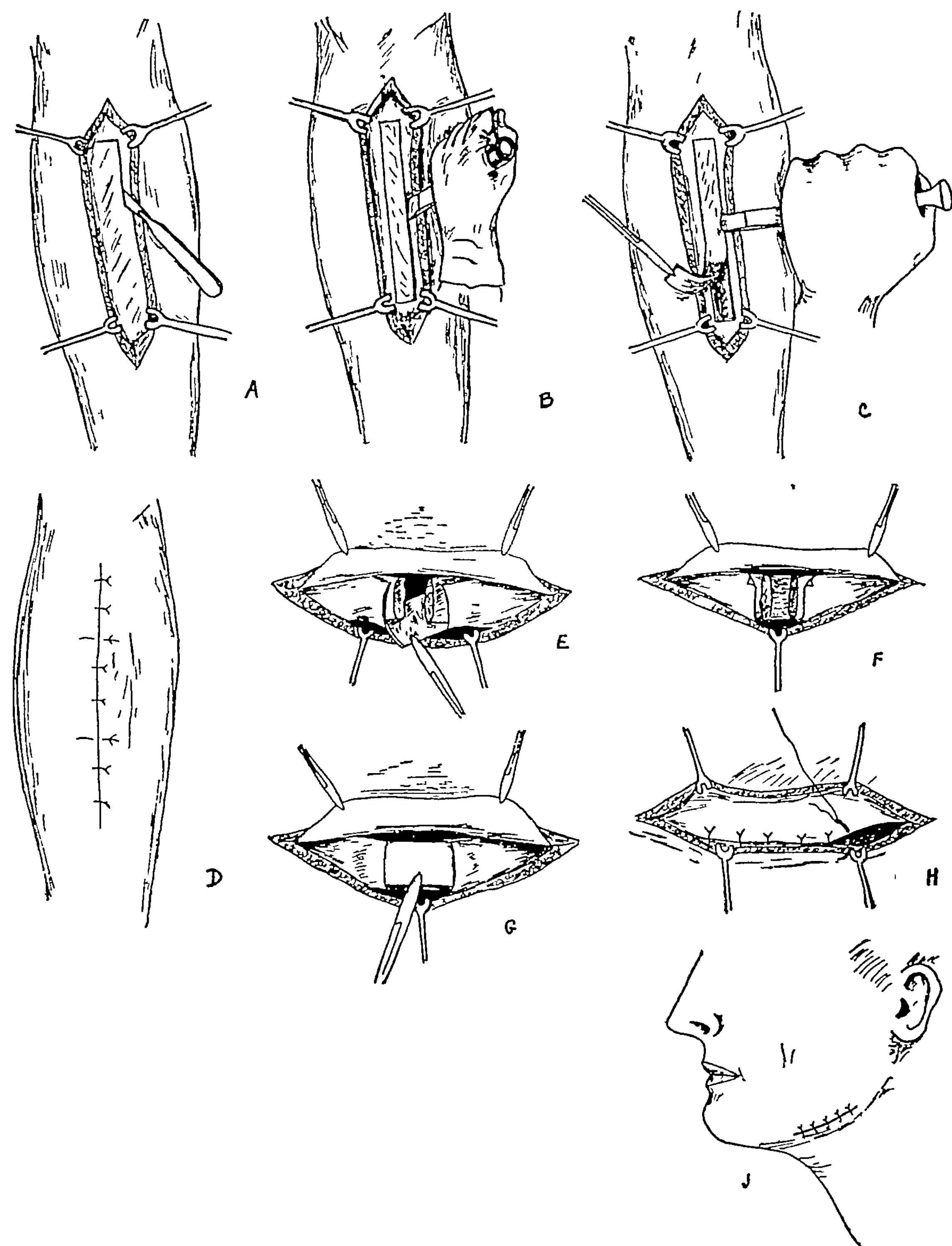


FIG 135 —Osteoperiosteal graft from tibia *A*, periosteum over antero-internal surface of tibia exposed and outline of graft traced in periosteum with knife, *B*, graft outlined with chisel which penetrates bone to depth of about 1 mm , *C*, osteoperiosteal graft removed with chisel held almost parallel to surface of bone, *D*, leg incision closed, *E*, piece of osteoperiosteal graft inserted in pocket beneath mandibular fragments, *F*, deep piece of graft in place, *G*, second piece of graft placed in pocket over mandibular fragments, *H*, suture of deeper layer of soft tissues over site of grafts, *J*, closure of skin incision (Ivy and Curtis Dental Cosmos, S S White Mfg Co)

and a thin shaving of bone with overlying periosteum, included within the outline traced, is removed. This graft is cut into two or three pieces, as desired. The skin wound in the leg is sutured with silkworm gut.

(c) One piece of graft is inserted with its ends in the subperiosteal pockets on the inner side of the mandibular fragments. Another piece is inserted on the outer aspects of the fragments, the bony surfaces of the grafts facing each other across the gap. It is necessary that the grafts be in contact with the previously freshened bone ends. If desired, a third piece of graft can be placed along the lower border of the defect between the fragments. No direct fixation is used beyond suturing the deep tissues over the grafts and ends of the bone. The skin wound is closed with dermal sutures, usually without drainage.

The following case, not of traumatic origin, but of pathological fracture of the mandible with loss of substance due to osteomyelitis, illustrates



FIG. 136.—Case H. C. Retraction of chin due to loss of substance of right side of mandible from osteomyelitis.



FIG. 137.—Case H. C. Deviation of chin to right side.

the use of the osteoperiosteal graft. The methods employed are equally applicable to traumatic cases. A boy, aged six years, gave the following history. At the age of thirteen months osteomyelitis of the mandible began. This was diagnosed at the time as tuberculous, and required incision and drainage over a long period, the process being finally arrested after removal of a sequestrum from the right side of the mandible at three years of age. Examination showed a rather poorly-nourished boy, aged six years, with a visible deformity of the face. The chin was drawn back (Fig. 136), and deviated toward the right side (Fig. 137). The teeth were of poor quality, and those of the left side and front of the mandible were drawn over toward the right, the lower front teeth occluding a considerable distance behind the upper teeth. In the right premolar region there was a gap in the mandible, the two portions being freely movable, and there were no erupted teeth in the short segment on the right side

By manipulation it was easily possible to bring the lower teeth into approximately correct occlusion with the upper teeth

Radiographic examination showed a defect involving the entire thickness of the mandible in the right premolar region (Fig 138) When the segments were reduced this defect appeared to be about 1 inch in length The roentgen-ray revealed a partially developed unerupted molar tooth in the right segment

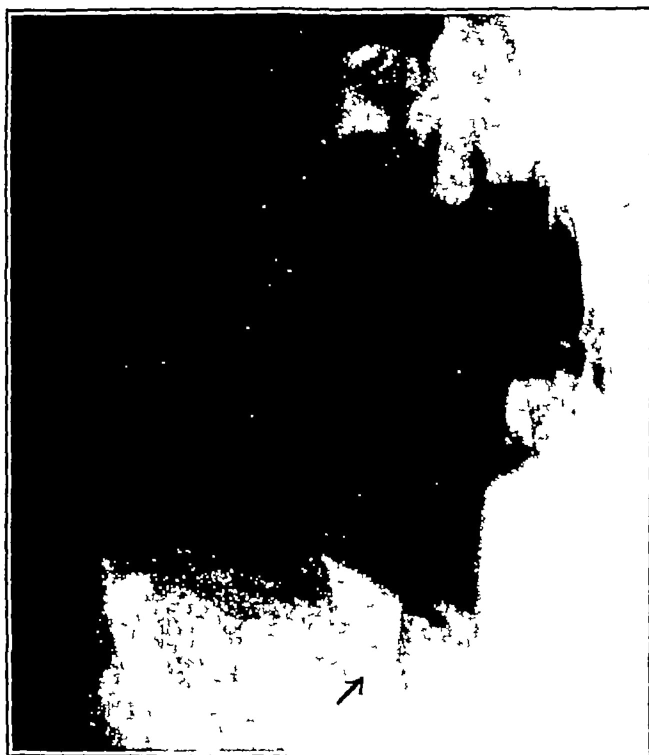


Fig 138 —Case H C Roentgenogram showing gap in right side of mandible

The patient thus had a visible facial deformity, with crippling of the function of mastication due to malocclusion of the teeth and instability of the lower jaw

Treatment —The first indication was reduction and fixation of the mandibular fragments in as nearly normal position as possible The teeth were not sufficiently strong to rely on them alone for retention of interdental splints or wires Recourse was had therefore to direct fixation of the bone by means of external appliances A plaster of Paris head cap was made, with a heavy coat-hanger wire extending down in front of the face. This was followed, under ether anesthesia, by circumferential wiring of the mandible to the left of the symphysis, the ends of the brass wire, after twisting them together, were brought out near the left corner of the mouth and fastened to the heavy wire on the head cap This made traction to draw the chin from right to left and also forward until the lower teeth came into the best possible occlusion with the upper Further stabilization was obtained by wiring some of the upper and lower teeth

preferred if the gap in the mandible exceeds 2 cm, and especially if the external contour of the face shows the deficiency The crest of the ilium furnishes a large piece of bone, of porous structure closely resembling that of the mandible, it is easily penetrated by new vascular supply, and can be readily cut to suitable shape. The disability produced by removal of the graft is quite temporary and the danger negligible.



Fig 143 —Case H C Front view after operation



Fig 144 —Case H C Extent of mouth opening after operation

The *technique* of grafting the mandible from the crest of the ilium is also divided into three stages (*a*) The skin incision over the mandibular defect is the same as for the osteoperiosteal method A second layer of deeper tissues is then raised, exposing the bone Scar tissue between the fragments is carefully removed, and the ends of the bone are thoroughly exposed and bevelled slightly to create broad freshened surfaces (Fig 145). A hole is drilled in the end of each fragment for the passage of a No 24-gauge brass wire Bleeding is arrested The length of the gap is measured with a probe

(*b*) An incision is made along the crest of the ilium of the same side as the jaw defect, down to the periosteum, beginning at the anterior-superior spine, back as far as necessary The muscles attached to the outer and inner lips of the crest are stripped down, and a piece of bone is removed with a metacarpal saw, beginning at the anterior-superior spine and working backward The graft comprises the full width of the crest of the ilium and should be of sufficient length and depth to fill the gap in the mandible, allowance being made for slightly overlapping the mandibular fragments at each end The detached muscles are brought over the site of removal of the graft and sutured together with chromicized catgut, and the skin of the iliac wound is closed with dermal sutures A small rubber tissue drain may be inserted for twenty-four hours

(*c*) Any shreds of muscle are removed from the graft, but periosteum is allowed to remain. The ends are slightly bevelled and holes drilled in

them The wires attached to the mandibular fragments are then passed through the holes and twisted so that the graft fits snugly in contact with the mandibular fragments We prefer wire bone sutures to catgut or

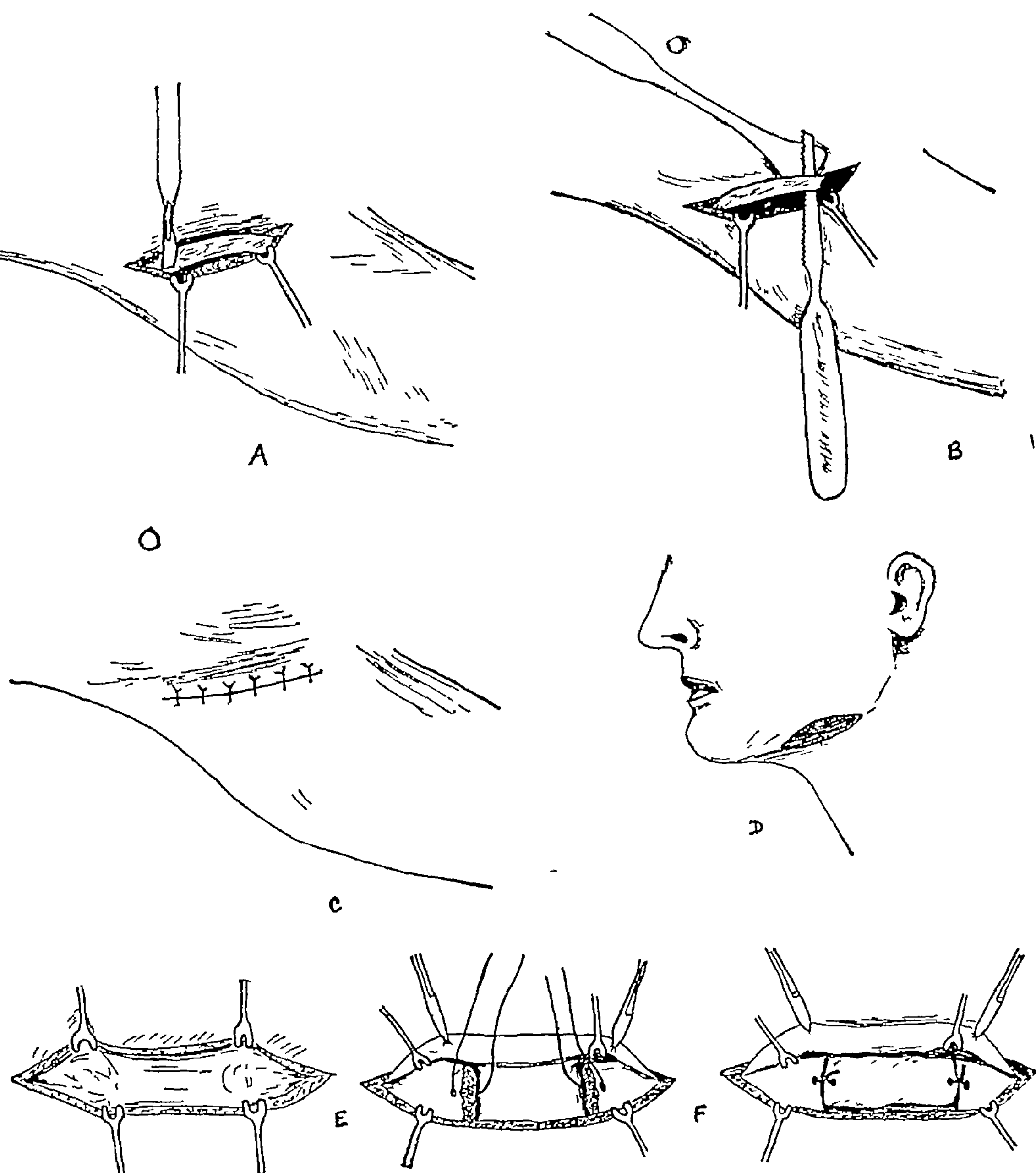


FIG 145 —Graft from crest of ilium A, crest of ilium exposed and muscles detached, B, graft removed with saw, beginning at anterior-superior spine, C, skin incision closed, D, skin incision over mandibular defect, E, deep tissues overlying bone defect exposed, F, ends of mandibular fragments exposed and wire passed through holes drilled in the bone, G, iliac graft placed in mandibular defect (Ivy and Curtis Dental Cosmos, S S White Mfg Co)

kangaroo tendon, because a very much firmer contact can be obtained The ends of the wires are cut off short and turned over so that they will not project into the soft tissues The wires usually remain permanently without causing irritation, but they can easily be removed later if desired.

The layer of deeper soft tissues is sutured with catgut to cover the bone and the skin flap closed with interrupted dermal sutures, usually without drainage.

Postoperative Treatment —The wire fixation on the teeth is kept in place for about twelve weeks after the graft operation After eight or nine weeks the upper and lower teeth can be disconnected at intervals to permit gentle exercise and to stimulate bone consolidation Union should be firm in about three months, after which it is usually possible to have the missing teeth replaced by an artificial denture

The following is a brief description of a case illustrating the application of these principles Patient was shot with a large caliber pistol, the bullet entering the left side of the face, shattering the left side of the mandible and remaining lodged in the tissues (Fig 146) Shortly after the accident



Fig 146 —Case H H Roentgenogram showing comminution of left side of mandible and bullet in tissues

an operation was performed for removal of detached teeth, bone fragments and bullet, and a cast metal splint was inserted in the mouth to hold the fragments in position Seven months after the injury the patient was referred to us for further treatment At this time a gap of about $1\frac{1}{2}$ inches was found on the left side of the mandible This defect extended from just posterior to the left first incisor tooth to about the second molar region There were no teeth in a short bone fragment posterior to the defect Only four teeth were present in the main mandibular fragment The metal splint was still in position, and a saddle resting on the gum kept the short posterior fragment down in place, but there was ulceration of the soft tissues from undue pressure On removal of the splint the main mandibular fragment was found to be freely movable and showed a tendency to swing over to the left side, throwing the teeth out of occlusion

and causing marked external deformity (Fig 147) The metal splint was discarded and the remaining lower teeth were brought into correct occlusion with the upper teeth and fastened by means of half-round wire arches The short posterior fragment was prevented from tilting upward by wire

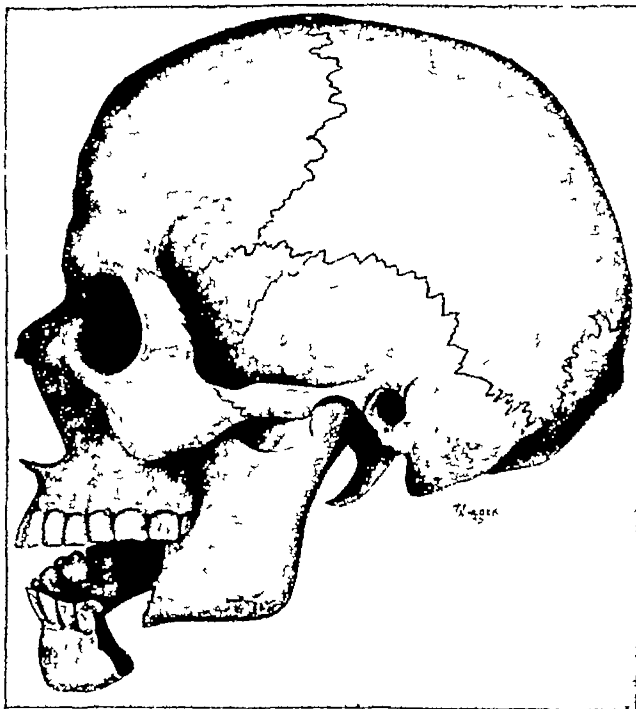


FIG 147 —Case H H Diagrammatic representation of deformity before operation (Ivy and Curtis Surg , Gynec and Obst)



FIG 148 —Case H H Roentgenogram showing wire passed through left angle of mandible, to be attached to head cap

passed through the left angle (Fig 148) and connected to a plaster of Paris head cap (Fig 149) (For technique see p 69) One week later the gap in the mandible was filled by a bone graft from the crest of the ilium



FIG 149 —Head cap completed with traction by elastic band and wire through posterior fragment of mandible (Ivy and Curtis Surg Clin North America, W B Saunders Company)



FIG 150 —Case H H Roentgenogram showing mandibular defect filled by graft from crest of ilium

(Fig 150) The head cap and traction wire were removed five weeks after the bone graft operation Fifteen weeks after insertion of the graft the wires connecting the teeth were cut and bone consolidation was found

to be practically complete The patient could open the mouth without any lateral deviation of the mandible, and the jaw was in condition for early insertion of an artificial denture (Fig 151)



Fig 151 —Case H H After restoration of continuity of mandible by graft, showing normal mouth opening and absence of deviation of chin

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CHAPTER V

FRACTURES OF THE MAXILLA

FRACTURES of the maxilla are much less common than those of the mandible, although they are being seen with increasing frequency, because of automobile accidents They are often associated with extensive head injuries, fracture of the base or the vault of the skull, and of other facial bones, such as the malar, nasal, and frontal, as well as the mandible.

Owing to the absence of powerful muscle attachments to the maxilla, displacement of fragments is not due to muscular pull, but to the direction of the traumatizing force and sometimes to gravity

CLASSIFICATION OF FRACTURES OF THE MAXILLA

Most fractures of the maxilla fall under the following heads.

1 Fracture of the alveolar process alone

2 Unilateral fracture across the facial aspect above the roots of the teeth, and through the hard palate

3 Bilateral horizontal fracture above the palate and below the orbital plates

4 Extensive comminution and crushing of the upper part of the maxillæ, complicated by fracture of the nasal and other bones

1. **Fracture of the Alveolar Process Alone.**—Fracture of the alveolar process alone may occur in the extraction of teeth The tuberosity is occasionally fractured during extraction of the third molar A blunt localized force, such as by a thick stick against the teeth, may result in this type of fracture In addition to the break in the bone, tooth roots may be fractured, or teeth may be broken off There is usually more or less displacement of the fragment, with malocclusion of the teeth, and gentle manipulation of the teeth will reveal mobility of the loosened fragment The roentgen-ray is useful in indicating the extent of the fracture, and also involvement of tooth roots

Treatment —Any hopelessly detached and fractured teeth and roots should be removed If the fragment of alveolar process is covered by and attached to overlying gum tissue, it is often possible to obtain union by a splint or arch wire fastened to teeth in the fragment and to those of the sound portion of the jaw, or the teeth in a sound portion of the maxilla can be fixed in occlusion with corresponding mandibular teeth by means of wires If the fragment is exposed by detachment of overlying soft tissue it is generally necessary to remove it as necrosis will almost certainly occur

2 **Unilateral Fracture of the Maxilla.**—Unilateral fracture of the maxilla is usually caused by direct force coming from in front or from one side In addition to the symptoms of contusion of the side of the face, the entire

maxillary dental arch on the side affected is usually depressed (Fig 152) and may be forced inward (Fig 153), causing a thickening of the palate due to overlapping at the palatine suture (Fig 154) Occasionally, the fragment will be forced outward (Fig 155), causing a spreading of the

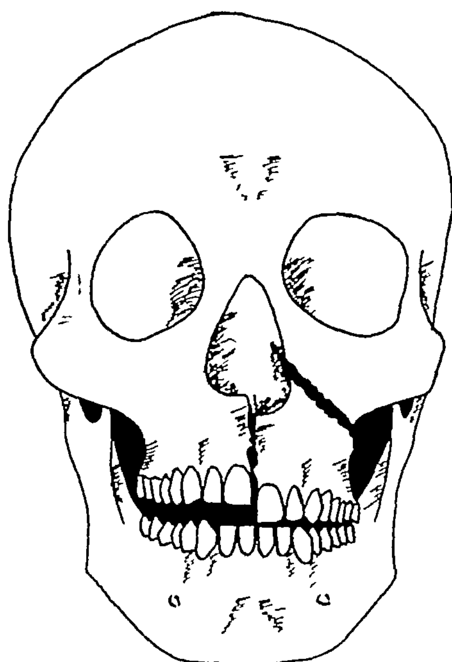


Fig 152 —Unilateral fracture of maxilla, showing downward displacement

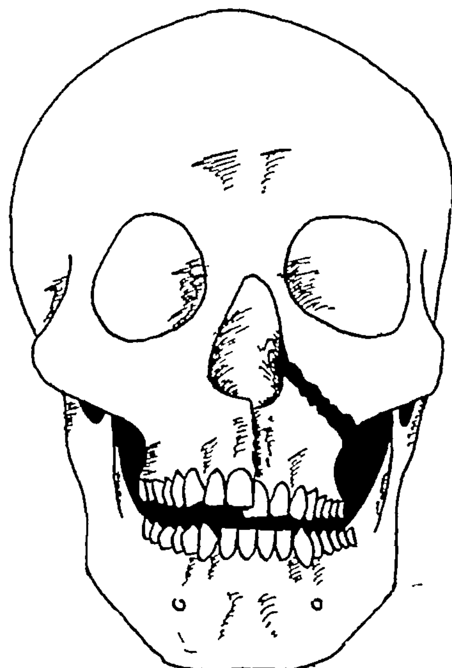


Fig 153 —Unilateral fracture of maxilla, showing downward and inward displacement

dental arch on that side By gentle manipulation mobility of the fragment can be readily detected Roentgen-ray examination is useful in determining the extent of the fracture, relationship of teeth, etc The maxillary

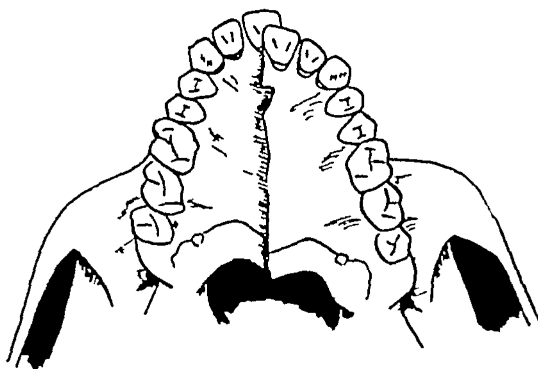


Fig 154 —Unilateral fracture of maxilla, showing overlapping at median palatal suture

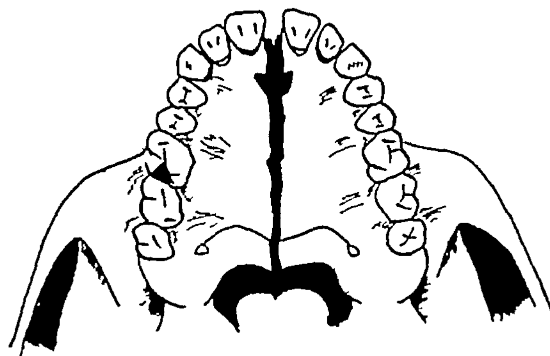


Fig 155 —Unilateral fracture of maxilla, showing separation at median palatal suture

sinus may be filled with blood clot which usually undergoes absorption or disintegration without symptoms, but which may become infected

Treatment—Many cases can be successfully treated by pushing the fragment back in place until the teeth are in occlusion and then wiring the

teeth of the *sound* side of the maxilla to those of the mandible, either by the eyelet method or by half-round arch wires (Fig 156)

Immediate complete reduction with restoration of normal occlusion of the teeth may not be possible With displacement of the teeth toward the median line, gradual spreading of the dental arch may be necessary, by means of elastic or screw force The simplest form of apparatus to accomplish this, and which can be fitted without impression taking, soldering or other laboratory technique, is one similar to that described under fracture of the symphysis of the mandible (p 96). Separate half-round arch bars are applied to the teeth on each side of the upper jaw The ends

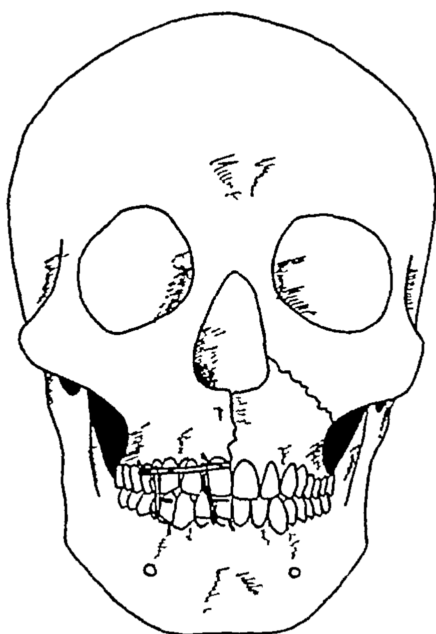


Fig 156 —Treatment of unilateral fracture of maxilla by wiring maxillary and mandibular teeth on sound side

of the bars are left long enough to overlap each other across the fracture in front The front end of each bar is bent to form a hook, and a small rubber band connecting the two hooked ends exerts force that causes the inwardly displaced fragment to move away from the median line When the teeth have reached a satisfactory occlusal relationship the upper and lower dental arches may be ligated together with brass wires In cases where this method does not work satisfactorily a good result may be obtained by a palatal jack-screw attached to orthodontic bands on the teeth on each side

Where the maxillary fragment is displaced outward, the dental arch may be narrowed by elastic bands running transversely or diagonally across the palate, being attached on each side to a half-round arch wire on the teeth One of these arches is molded to fit the vestibular surfaces of the teeth on each side The ends of the brass wire ligatures attaching each arch to the teeth are twisted on the palatal side of the teeth to form hooks, which afford attachments for the elastic bands (Fig. 157) Another

suitable method of narrowing the arch is by the use of Risdon's twisted wire arch bars as described on page 63

In case of maxillary sinus infection complicating the fracture, this will require appropriate treatment

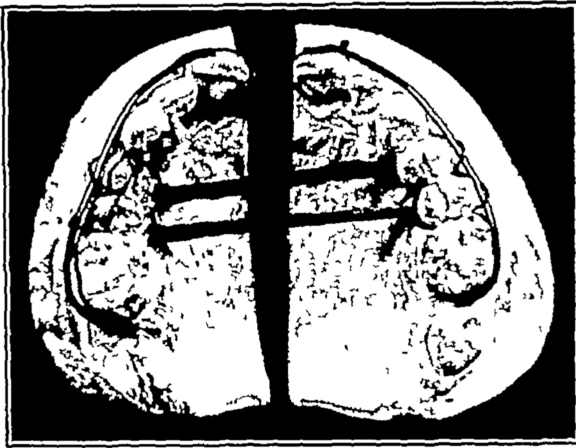


Fig 157 —Fracture through median palatal suture Two sides brought together by elastic force across palate

3 **Bilateral Horizontal Fracture.**—Bilateral horizontal fracture is usually caused by direct force from in front, such as by striking the steering wheel of a suddenly arrested automobile In the majority of cases the entire

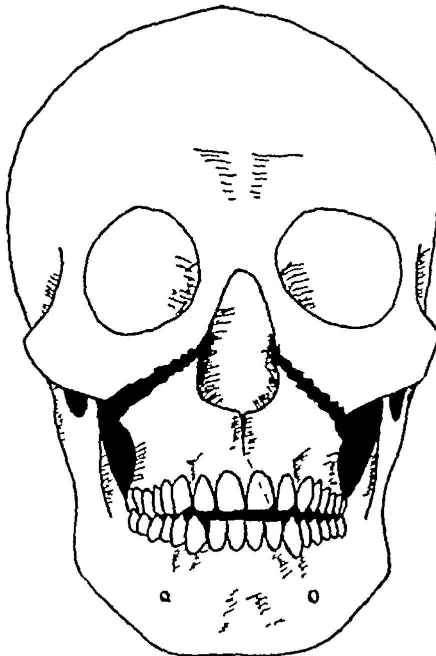


Fig 158 —Bilateral horizontal fracture of maxilla, showing downward displacement

maxilla is displaced backward and downward (Figs 158 and 159) The fracture may extend back through the pterygoid processes The entire dental arch can be moved as a unit The hard palate may be intact, or the case may be complicated by a longitudinal median fracture through

the palate with either spreading or narrowing of the dental arch (Fig 160) Here again symptoms of maxillary sinus infection may become manifest

Treatment —In bilateral fracture of the maxilla above the palate, fixation by means of the mandibular teeth is not advisable at first, because of the

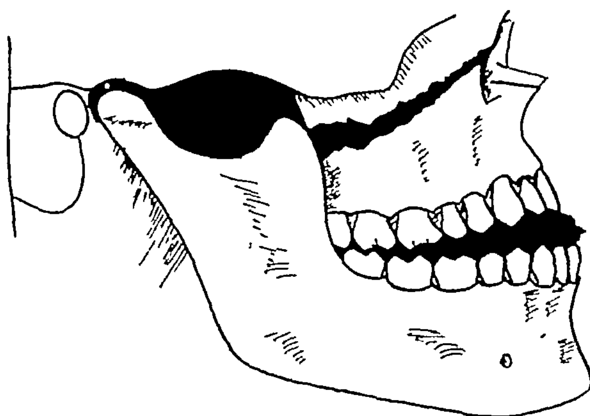


Fig 159 —Bilateral horizontal fracture of maxilla, showing backward and downward displacement

movability of the lower jaw Support here should be obtained from the cranium by means of a head apparatus and reversed Kingsley splint, as described by Marshall [4] A vulcanite or metal cap splint is made to fit the

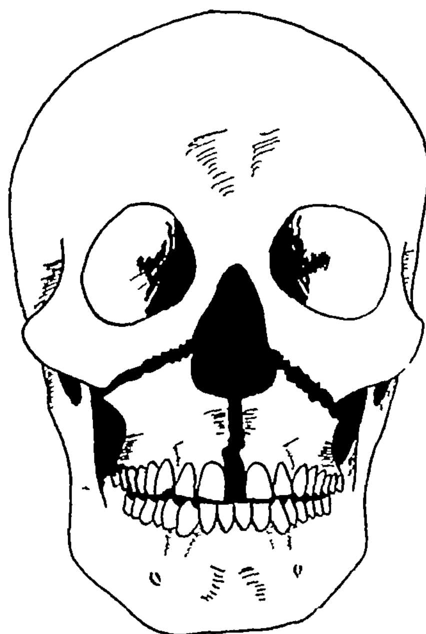


Fig 160 —Bilateral horizontal fracture of maxilla with median fracture through palatal suture

upper teeth From the outer sides of the splint heavy metal bars emerge at the corners of the mouth, passing back for a distance over the cheeks A plaster of Paris skull cap is made (see p 71), in which are embedded straps or hooks which can be connected with the bars emerging from the mouth to make traction in the desired direction When reduction has

been attained, the maxillary and mandibular teeth are fastened in occlusion until consolidation is complete We have had useful service in cases of this kind from an emergency apparatus consisting essentially of a metal impression tray to which heavy wire arms are soldered on each side for attachment to the head cap (Fig 161) This tray is secured to the teeth

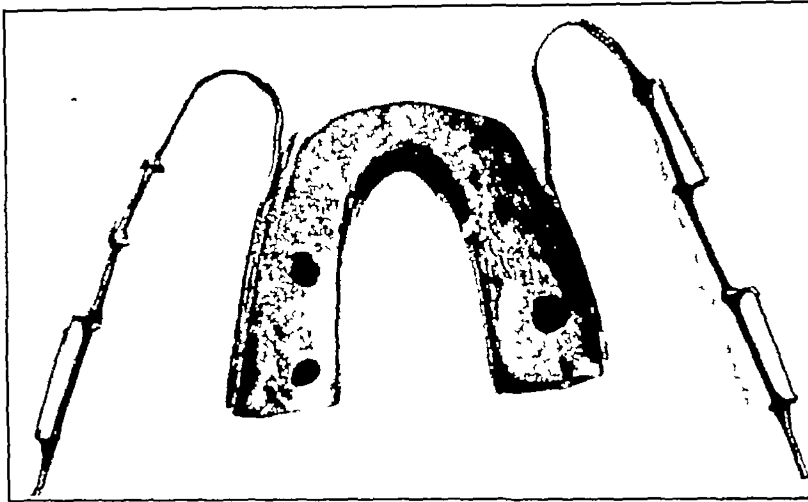


FIG 161 —Metal tray with arms extending out of mouth for attachment to head cap (Made by Dr E Howell Smith)

by dental impression compound and two or three ligature wires, thus avoiding the necessity of taking impressions and making special splints Another emergency apparatus consists of a heavy arch bar to be secured

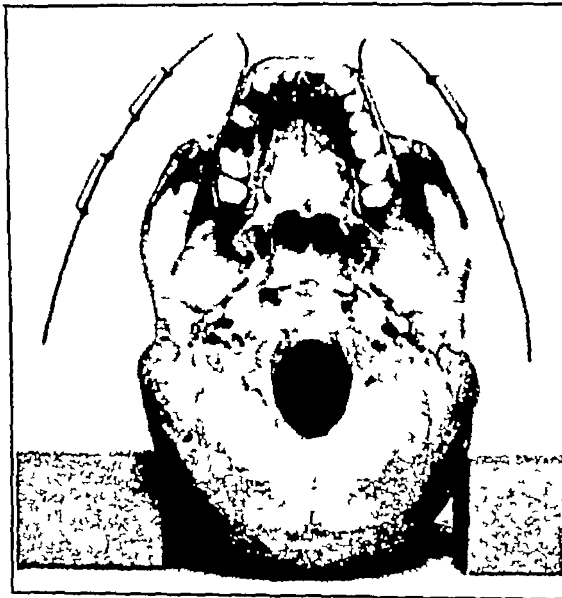


FIG 162 —Author's heavy arch bar secured to teeth with wire ligatures, for treatment of fracture of maxilla (Made by Dr E Howell Smith)

to the vestibular surfaces of the teeth with wire ligatures and provided with arms extending out of the mouth on each side for attachment to the head cap (Fig 162) This and the apparatus shown in Figure 161 were

made by Dr E Howell Smith They can be made in two or three sizes and kept on hand so as to be immediately applicable in any case when the need arises * Where these cases are complicated by fracture through the hard palate additional measures must be taken to correct the lateral displacement as described under Group 2 About six weeks is the average time for union to take place in these fractures

The following case illustrates the application of these principles

M D, female, aged twenty-one years, single, was struck down by an automobile while walking across the street, being rendered unconscious by head injuries She received emergency treatment at St Luke's Hospital, Bethlehem, Pa, by Dr W D Chase Three days later she was brought to the Graduate Hospital of the University of Pennsylvania, Philadelphia Here, the patient's face was found to be greatly swollen and battered, the eyelids being practically closed There was a deep transverse gash across the bridge of the nose with wide separation of its edges The nasal bones had been detached from the frontal bone above and driven over the nasal process of the right maxilla into the right orbit, with extensive comminution The nasal articulation of the frontal bone was exposed in the wound The external part of the nose below the wound was sagging downward and in a flattened condition due to lateral displacement of the septum The patient complained of malocclusion of the teeth and examination showed the entire maxillary dental arch to be displaced somewhat backward and slightly movable as a whole This indicated a bilateral transverse fracture of the maxilla

Very little suppuration was present in the nasal wound, the temperature was slightly elevated, and the general condition of the patient was good Owing to the severity and extent of the injury it was considered advisable first to attempt correction of the displacement of the bones about the nasal wound, under ether anesthesia It was necessary to remove some of the comminuted nasal bone fragments The portion which, together with the nasal process of the maxilla, had been driven into the right orbit could be lifted over into fairly good position, but difficulty was experienced in retaining it, so that the plan advocated by Blair[2] was employed A small incision was made just mesially to and below the inner canthus of the right eye, exposing the loose bone fragment A piece of soft brass wire, No 24-gauge, was carried down through the incision by means of a heavy curved needle, across the nasal cavity, transfixing the cartilaginous septum, to emerge through the mucous membrane of the vestibule of the opposite side of the mouth The other end of the wire was then threaded through the needle and passed around the loose bone fragment, being then brought down in the same manner into the vestibule of the mouth The displaced bone fragment was then firmly anchored in position by attaching the ends of the wire to the canine and first premolar teeth of the left maxilla (Fig 163) The retracted edges of the irregular skin wound were undermined, and almost completely approximated by sutures Vaselin gauze packs

* This and the apparatus shown in Figure 161 can be obtained from George P Pilling & Sons Company, Philadelphia

were inserted into each nasal chamber for twenty-four hours. The complication chiefly to be feared was meningitis, but the temperature returned to normal after three days, both the accidental wound and the small



FIG 163 —Case M D Roentgenogram showing wire looped around nasal process of maxilla and fastened to tooth on opposite side of upper jaw (Blair's method)



FIG 164 —Forward traction on upper jaw by bar coming down in front of face from head cap

operative incision healed satisfactorily, and the swelling of the soft tissues gradually subsided

Five days later, attention was given to the maxillary fracture The heavy wire arch appliance shown in Figure 162 was ligated to the upper

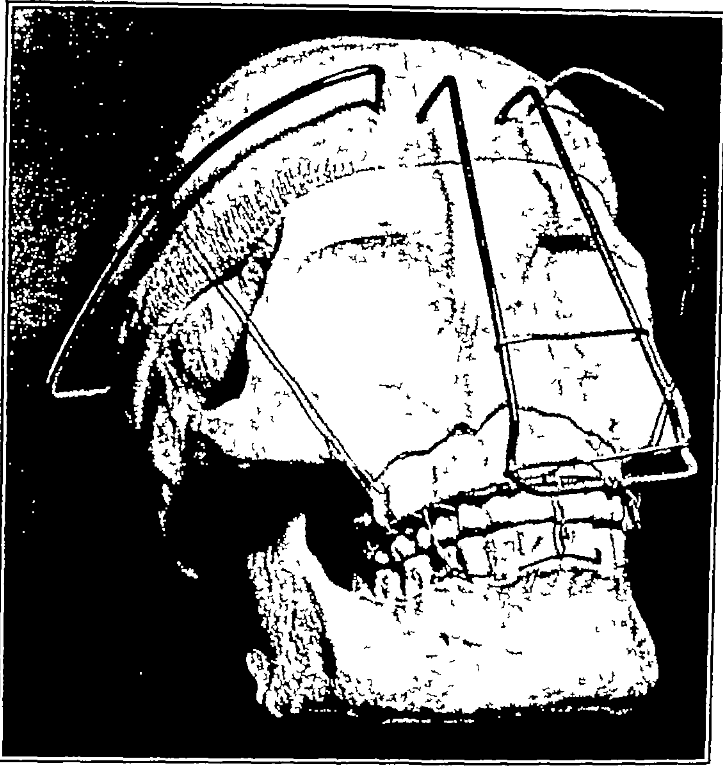


FIG 165 —Federspiel's method of fixation of fracture of maxilla Wire from teeth passes over malar to head cap



FIG 166 —Federspiel's method—modification to be used in case complicated by fractured malar Wire from teeth passes beneath malar, holding the latter out



A



B

FIG 167 —*A*, Case of fractured maxilla showing Federspiel's method applied Also shows skeletal fixation for fracture of mandible *B*, Same case as shown in *A* several days later

teeth, and a plaster head cap was applied With light leather straps traction was then made possible on the maxilla (Figs 168 and 169), and in a few days the normal occlusion of the teeth was reestablished Sufficient stability of the upper jaw was noted after three weeks and the appliances were removed Six weeks after insertion the brass wire around the nasal fragment was removed under local anesthesia Respiration through the nose was found to be free, and the scar of the accidental wound was becoming much less noticeable Later improvement in the nasal profile is contemplated by implantation of costal cartilage

Where backward displacement of the fragment is marked, forward traction can be made by means of a bar coming down in front of the face from the head cap A wire runs from the anterior part of the arch bar on the teeth to the lower end of this bar, and, in a few days, the upper jaw and teeth will have come forward sufficiently so that correct occlusion is reestablished The teeth can then be wired together until union occurs (Fig 164)

We have largely dispensed with all apparatus for fractures of the upper jaw which rely on external cheek bars for control of the fragments We now use direct traction from arch bars ligated to the teeth of the upper jaw to the plaster head cap This was first described by Federspiel[8] A loop of 24-gauge brass ligature wire, 12 inches in length, is passed around the German silver arch bar in the region of the second premolar on each side The two free ends are threaded in the eyelet of a 4-inch cutting edge straight needle which is passed upward through the cheek over the malar prominence emerging 1 cm outward from the external canthus The delivered ends are removed from the needle and fastened over the bar in the head cap—then tightened as the fragments of the upper jaw—or the intact upper jaw—are manually reduced by the assistant If the malar bone has been pushed backward the wires are inserted behind it to emerge through the skin just back of the orbital ridge (Figs 165, 166 and 167)

4 **Bilateral Fracture With Extensive Comminution and Crushing of the Upper Part of the Face.**—This sometimes occurs as the result of a gunshot wound or a very severe trauma from below, forcing the maxilla up into the more fragile bones above The maxilla loses all support from the base of the skull, which itself is frequently fractured also (Fig 170) Infection from the nasal fossa and sinuses is a common complication, and meningitis is not unusual

Treatment—The general condition of the patient must always be considered first Too strenuous attempts at replacing the bone may result in opening up avenues of infection to the meninges Before attempting reduction it is best to wait at least a few days until the general condition of the patient has improved Drainage from involved nasal accessory sinuses should be provided, preferably through the mouth and nose, and cleansing maintained by frequent irrigation

Means of Fixation—Here it will be realized that upward pressure against the skull cannot be employed since the normal length of the face would not be preserved A metal or vulcanite splint is made for the maxillary teeth,

with bars extending on each side from the corners of the mouth, but instead of making upward pressure with straps, the dental splint must be suspended rigidly at the proper distance from the skull cap by means of solid vertical bars or rods



FIG 168 —Case M D Bilateral horizontal fracture of maxilla Profile view with apparatus in place



FIG 169 —Case M D Front view with apparatus in place

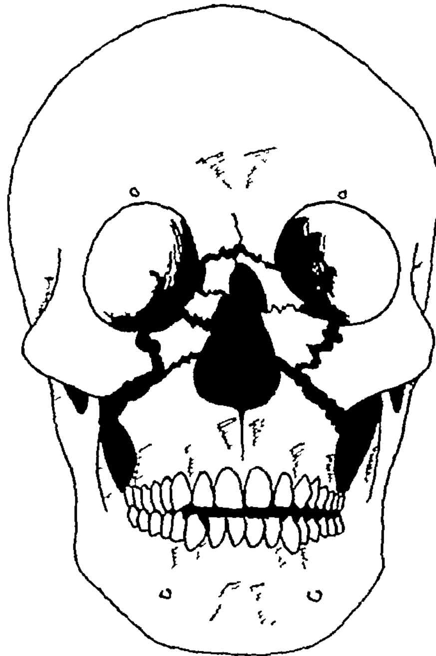


FIG 170 —Bilateral fracture of maxilla with extensive comminution and crushing of the upper part of the face

The following case was unusual because of displacement of the fractured portion of the maxilla forward instead of backward.

W R, male, aged forty-six years, was admitted to the hospital on November 7, 1928, with the following history On October 28, 1928, while looking up, he was struck on the right cheek and nose by a falling steel window sash, the blow rendered him unconscious for one hour There

was a large contused lacerated wound of the right cheek, extending through into the maxillary sinus and tearing the mucous membrane of the mouth at the site of the first molar tooth, which was missing The right and left maxillæ in front of the second molar regions were freely movable as a unit, the fracture extending transversely from one side to the other below the nasal bones, and across the hard palate The dental arch was displaced forward about the width of a molar tooth, so that the maxillary anterior teeth projected about 2 cm in front of the mandibular teeth (Fig 171)

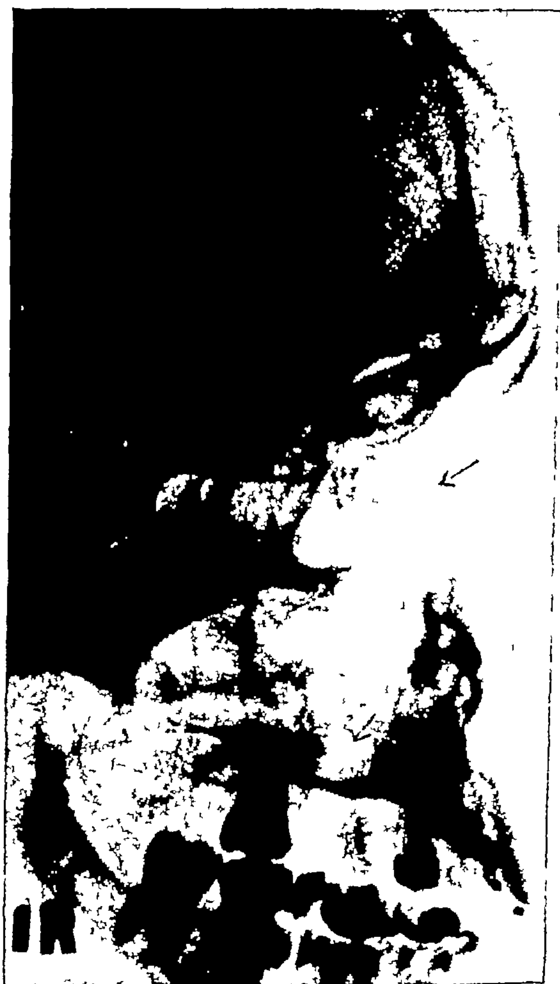


FIG 171 —Case W R Roentgenogram showing forward displacement of maxillary fragment.

There was also considerable downward displacement Immediately after the injury, the wound through the cheek had been explored, several loose bone fragments removed from around the opening into the maxillary sinus, and through-and-through drainage into the mouth instituted The wound and the maxillary sinus were kept clean by frequent irrigation with boric acid solution

November 9, twelve days after the accident, the patient was received on our service and reduction apparatus was applied as follows A plaster of Paris head cap was first made In the plaster on each side were corpor-

ated hooks made of coat-hanger wire, one in front of and above the ear and another below and behind the ear A heavy wire was attached to the outer edge of a shallow aluminum impression tray on each side and shaped so that it would emerge from the corner of the mouth and curve backward over the cheek (Fig 161) The impression tray was fixed to the maxillary arch with a small amount of dental impression compound Backward and upward traction was then made on the maxilla by heavy rubber bands connecting the hooks on the head gear with the wires emerging from the mouth (Figs 172 and 173) It will be noted that the reduction



Fig 172 Fig 173

Fig 172 —Case W R Profile view, showing apparatus in place
Fig 173 —Case W R Front view, showing apparatus in place

apparatus was applied two days after the patient was first seen A much greater delay would have been necessary had a special apparatus been made for the case from impressions and casts of the teeth In ten days, by the method described, the fractured maxilla was drawn back into normal position so that on November 19 the apparatus was removed and the teeth were found to be in good occlusion (Fig 174) The maxillary and mandibular teeth were then wired in occlusion for a further period of two weeks Examination then showed firm union of the maxilla with good occlusion of the teeth (Fig 175) The external wound had entirely healed, leaving a vertical depressed scar on the right cheek, which was later corrected by a simple operation under local anesthesia

Adams Method —Another very useful method of fixation of fractures of the maxilla is advocated by Adams,[1] of Memphis By this method the use of external bars and a plaster head cap is avoided For a complete bilateral fracture of the maxilla alone, Adams drills a hole in the lower orbital border through a small skin incision The maxilla is held up in position by a stainless steel wire attached below to a premolar tooth and the ends brought up and fastened together after one end has been passed through the hole in the lower rim of the orbit (Fig 176) In case the malar and orbital border are fractured and displaced on one side, the wire from the teeth is carried up beneath the malar bone and passed through a hole

drilled in the frontal bone at the outer side of the upper orbital margin (Figs. 177 and 178) The occlusion of the teeth is used as a guide to accurate reduction, and the method is used in conjunction with ligature wires on the teeth when necessary



FIG 174 —Case W R. Showing good occlusion of teeth after reduction by apparatus



FIG 175 —Case W R Roentgenogram after bone fragment had been drawn back into place

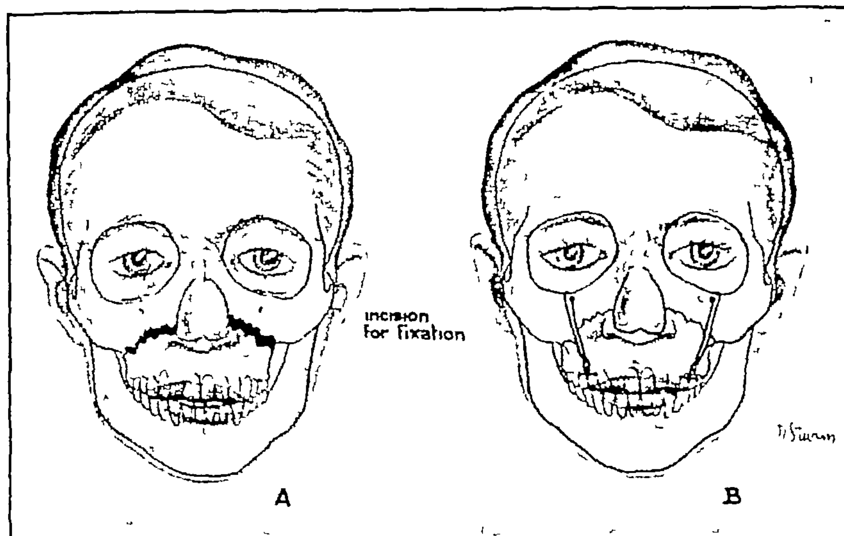


Fig 176 —Adams' method of direct fixation in fracture of maxilla by wire on each side passed up from teeth to hole drilled in lower orbital margin (Surgery, 12, 533, 1942)

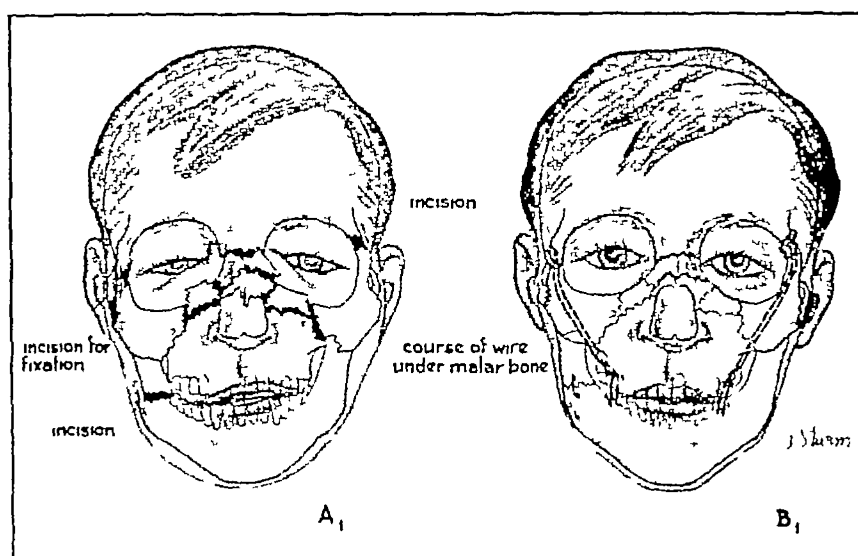


Fig 177 —Adams' method in case complicated by fracture of malar, front view (Surgery, 12, 533, 1942)

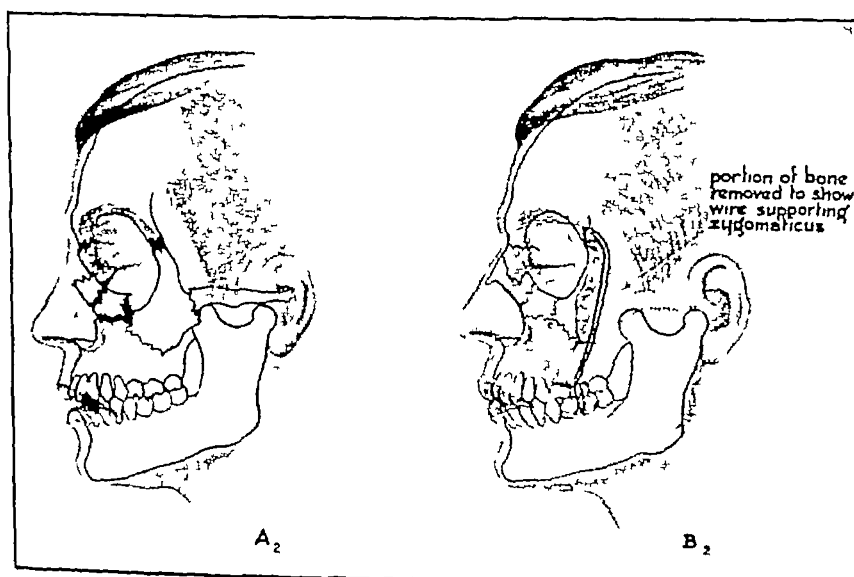


Fig 178 —Same as in Figure 177, side view (Surgery, 12, 533, 1942)

The following is an example of a case of fracture of the maxilla complicated by fracture of the mandible

The patient, a student nurse, aged twenty years, was taken to the hospital in an unconscious condition after an automobile accident There was a fracture through the median suture of the hard palate and above the teeth on the right side This permitted free movement of all of the teeth of the right maxilla together with the fragment The fragment was displaced upward posteriorly and pushed out laterally, giving a separation of about ½ inch between the right and left maxillary first incisors The posterior teeth in the fragment did not occlude with the mandibular teeth, being displaced upward and outward

There was also a fracture of the right side of the mandible between the canine and first premolar teeth The usual displacement was present here, *viz*, the fragment posterior to the fracture was drawn up by the levator muscles, while the fragment anterior to the fracture was drawn down by the depressor muscles attached to the symphysis

Treatment —An apparatus was applied to the maxillary teeth similar to that shown in Figure 157, the hooks on each side being connected across the palate with rubber bands, so that traction was made on the outwardly displaced fragment toward the median line Two separate pieces of half-round arch wire were attached to the teeth of the mandibular fragments, and downward traction was made on the right maxillary fragment by connecting the teeth in it by an elastic band to the arch wire on the corresponding mandibular teeth After ten days the right maxillary fragment had been brought downward and inward to correct position, the elastic bands were removed, and the upper and lower teeth were wired firmly in occlusion for four more weeks, after which consolidation of the fractures was found to be complete

We frequently see patients with severe, complicated fractures of both jaws and the following 2 cases will show what may be done for them

CASE 1 —A F, female, aged twenty-one years, was riding beside the driver of an automobile when the car crashed with another and she was brought to the Presbyterian Hospital, Philadelphia There was marked edema and ecchymosis about the left eye and cheek with a subconjunctival hemorrhage of the left eye There was a depressed fracture of the left zygoma and a complete bilateral horizontal fracture of the maxilla with downward and backward displacement The mandible was fractured at the neck of the left condyle, through the left angle and also the symphysis The left condyle was displaced forward, the left ramus was displaced outward and upward and contained the crown and posterior root of the third molar The left body was displaced downward and inward The right ulna was fractured and there were jagged wounds over the right occipital region, over the left clavicle and the upper part of the left thigh There was an oblique cut completely through the left lower lip about 1 inch in length These wounds were débrided and closed with rubber tissue drainage Within a few hours we made a plaster head cap, with a window for the scalp wound, with side and front coat-hanger wire bars Half-round

arch bars were ligated to the teeth of both jaws, the lower in two sections The maxilla was freely movable The left first incisor was in the line of fracture and removed as was the broken root of the third molar The crown and posterior root of this tooth were allowed to remain in the ramus for two reasons, even though infection was invited by so doing First, to prevent riding up of the posterior fragment, and, second, to enable us to bring the displaced ramus downward and inward by locking its cusps under those of the approximating upper molars The fragments were reduced, the two jaws immobilized by connecting their arch bars, and the whole fixed to the head cap by means of wires from the lower arch bars upward and forward to the anterior head cap bar The depressed zygoma was elevated by Gillies' method (page 148) Infections developed at both the symphysis and the angle which required external drainage We fully expected this In two weeks the head cap was removed, the jaws remaining fixed together In another two weeks a second lower incisor was removed, a crib replaced the lower arch bar and the jaws were again fastened together Seven weeks after the accident all wounds were healed, the jaws were in good position and they were separated There was a slight trismus which disappeared in another week Two weeks later the crib and upper arch bar were removed, also what remained of the third molar, and a partial denture for the missing teeth made for her

Case 2 —A C, male, aged twenty-one years, was in an automobile accident and taken to a hospital in a neighboring city An unsuccessful attempt was made to reduce the fractures of the jaws and a week later he was brought to the Presbyterian Hospital There was a complete bilateral horizontal fracture of the maxilla with a loss of all premolars and molars on the left side, severe tearing of the mucosa and comminution of the underlying bone, and with backward and downward displacement The six anterior teeth were chipped and loose In the mandible the six anterior teeth attached to the alveolar process were pushed backward under the tongue at an angle of 90 degrees There was an oblique complete fracture of the right body extending backward and upward from beneath the first premolar to between the second and third molars, with characteristic displacement The following day a plaster head cap was applied with front and lateral bars Half-round arch bars were ligated to such teeth as were usable in both jaws and the posteriorly displaced fragment in the anterior lower jaw brought forward and fixed to the arch bar The right lower third molar was removed A lower trismus tray (Fig 128) was lined with a little hot modeling compound, applied to the upper teeth and connected to the head cap with extra heavy elastic bands The lower arch bar was connected to the upper bar by wires passed through several holes drilled in the trismus tray It was somewhat difficult to stabilize the upper tray because of the loss of substance of the left maxilla, but proper reduction and fixation of both jaws was eventually accomplished Ten days later the head cap was removed with the upper tray and the jaws again connected Three weeks later the connecting wires were cut and the upp bar removed After two more weeks the lower bar was removed Tl

anterior fragment was solid but the teeth loose The jaws were in good relationship and solid, and the patient was referred to his dentist for the removal of certain teeth, and artificial appliances

Edentulous Upper Jaw —If there are no teeth in the fractured upper jaw we have the choice of several methods of fixation to the head cap If the patient has a denture that has not been broken in the accident holes may be bored on each side in the region of the second premolars and the plate used to support the fragments by direct wiring through the cheek to the head cap If a denture is not available an upper impression tray can be trimmed and used in a similar manner—with a thin layer of softened modeling compound to adapt it to the palate If such a tray is not handy a piece of fairly firm lead-zinc-tin alloy plate can be shaped to simulate the tray Finally, if one prefers to use the external cheek bars, they can be vulcanized into a skeleton, universal upper denture and adapted to any upper jaw with modeling compound (Fig 179)

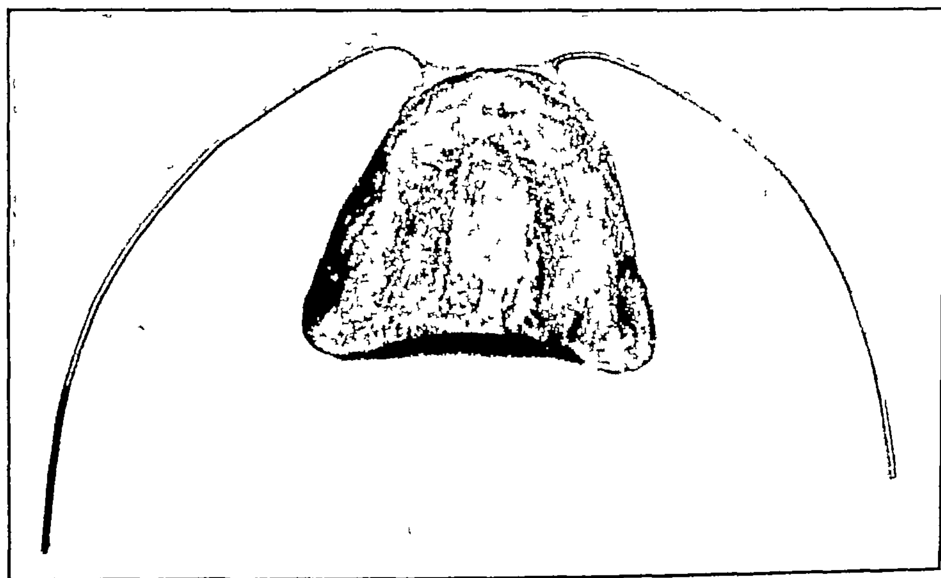


FIG 179 —Splint for use in fracture of edentulous upper jaw Vulcanite piece made from impression of patient's full upper denture, provided with external metal bars for attachment to plaster head cap

SUMMARY OF METHODS OF FIXATION OF FRACTURES OF THE MAXILLA

Type of Fracture	Method of Fixation
1 Unilateral fracture with little displacement	Eyelet method or half-round arch wire on teeth of sound side, fastened to mandibular teeth (p 123)
2 Unilateral fracture with displacement toward median line	Separate half-round arch wire on each side, ends overlapping and hooked for expanding elastic band (p 124)

3 Unilateral fracture with separation of two sides through median palatal suture	Separate half-round arch wire on each side, with hooks palatally for attachment of elastics to bring about contraction (p 124)
4 Bilateral horizontal fracture	Half-round arch wire to maxillary teeth, with extra-oral arms on each side for attachment to plaster head cap (pp 126, 132)
5 Bilateral fracture with comminution of bones above	Reversed Kingsley apparatus on maxillary teeth attached to head cap with rigid bars (p 132).

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CHAPTER VI

FRACTURES OF THE MALAR BONE AND ZYGOMATIC ARCH*

WHILE strictly not belonging to the subject of fractures of the jaw bones, it has been deemed proper to include a consideration of these injuries here, because of the proximity of the malar bone to the jaw bones proper and because a fracture of the maxilla or of the mandible is occasionally accompanied by a fracture of the malar bone Also, adequate information about these fractures is frequently lacking in text-books on surgery

At this point we desire to acknowledge gratitude to Gillies, Kilner and Stone[3] for their excellent work on this subject, and quote freely from their paper, which gives the clearest exposition of the injuries in question that we have seen anywhere

ETIOLOGY OF FRACTURES OF THE MALAR BONE AND ZYGOMATIC ARCH

"Fractures in this region are always due to direct violence They result, on the playing field, from blows with the point of the elbow or from kicks, they are produced by falls on the face, and they are especially common in motoring accidents "

DIAGNOSIS OF FRACTURES OF THE MALAR BONE AND ZYGOMATIC ARCH

"In a typical case diagnosis may be made at sight once the characteristic appearance has been fully recognized A peculiar facies is present, due chiefly to a certain flatness of contour and an absence of expression on the affected side Mobility and crepitus are rare, but by careful investigation the lines of fracture may often be detected by palpation The outstanding feature is a definite flattening of the cheek in its upper part and a fulness in its lower (Figs 180 and 181) This is made clearer when the area is examined from above after the traumatic effusion has subsided Depression, as compared with the opposite side, will often amount to ½ inch or more Examination from in front, assisted by palpation, reveals abnormal irregularity in the infra-orbital margin above the outer canthus, and sometimes in front of the ear, where the stump of the zygomatic process of the temporal bone stands out Palpation in the mouth reveals unnatural resistance to the finger passed along the ascending ramus of the mandible and between this and the maxilla

"At first there is much bruising and swelling, and these, as in cases of

* To be consistent with our plan of using modern anatomical nomenclature in this book, we ought to speak of the "zygoma" instead of the "malar bone," but we prefer to stick to the latter in order to distinguish it from the zygomatic arch

fracture of the nasal bones, mask the depression and fracture to such an extent that the underlying condition is entirely overlooked, in this way arises the necessity for late and difficult, instead of early and reasonably simple, treatment Frequently—almost always—there is unilateral epistaxis due to damage of the mucosa of the antrum. A 'black eye' is present, together with conjunctival ecchymosis Mastication is interfered with on account of pain produced by any attempt to use the masseter muscle, the attachments of which to the fractured and displaced bone are damaged Mechanical obstruction to jaw movements may also be present, and is due to the pressure of indriven fragments of the zygoma on the coronoid process or the temporal muscle (We have seen a case of depressed fracture of the malar bone in which the coronoid process of the mandible was



Fig 180 Fig 181

Fig 180 —Fracture of left malar bone before reduction
Fig 181 —Fracture of left malar bone, after reduction (Surg Clin North America, courtesy of W B Saunders Company)

also fractured —I and C) Pain may be traced to damage in the region of the infra-orbital nerve, while from the same cause there may be numbness over the area of distribution of this nerve The mandible usually deviates to the opposite side—a position which appears to be one of mandibular rest Limitation of eye movements may be present where there is much interference with the floor and margin of the orbit "

VARIETIES OF FRACTURE OF THE MALAR BONE AND ZYGOMATIC ARCH

"The malar bone represents a strong bone on fragile supports, and it is for this reason that, though the body of the bone is rarely broken, the four processes—frontal, orbital, maxillary, and zygomatic—are frequently sites

of fracture The bone is frequently separated from all its attachments and displaced *en masse* When the anatomical position and structure of this bony element are studied, together with its susceptibility to blows from very divergent angles, it will be obvious that the lines of fracture and the displacement produced will vary in almost every case Whilst blows at right angles to the surface produce direct depression and sometimes comminution of the body of the bone, blows from behind or from in front, from below or from above, produce sliding and tilting of the bone, and the degree of depression and displacement varies according to the direction and continuance of the force

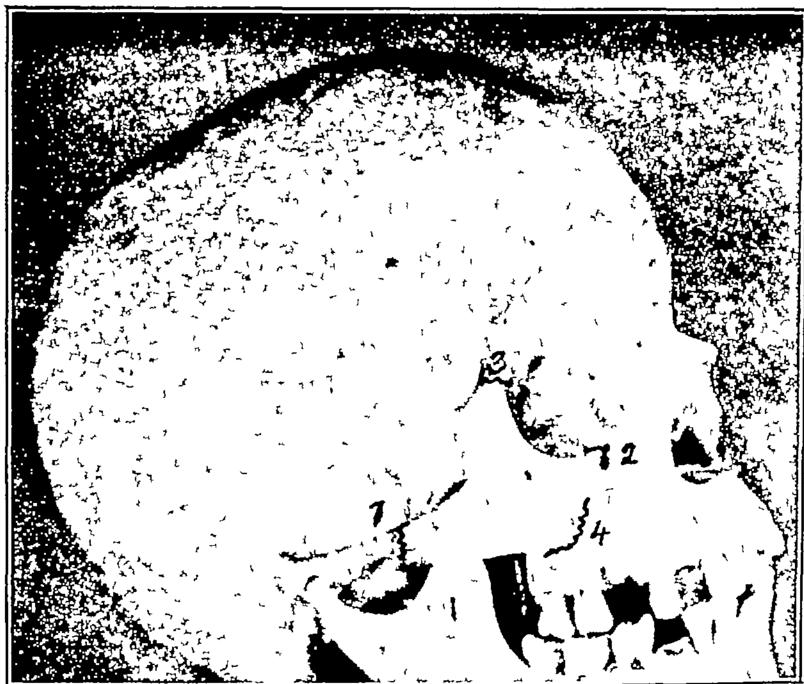


FIG 182 —Skull showing principal sites of fracture of malar bone 1, zygoma, 2, infra-orbital foramen region, 3, frontal process, 4, maxillo-malar articulation

"Four sites of fracture are found, corresponding with the points of articulation of the bone, namely (1) Zygoma, (2) infra-orbital foramen region—orbital process, (3) supero-external orbital margin—frontal process, (4) anterior wall of antrum—maxillo-malar articulation (Fig 182) Fracture of the infra-orbital margin occurs near its mid-point, and the inner extremity of the outer fragment may project forward and upward into the lower conjunctival fornix, where it can be seen and felt The fracture line extends downward through or near the infra-orbital foramen Fracture in the region of articulation with the frontal bone produces an irregularity of the orbital margin in its upper and outer quadrant, whilst a similar irregularity may be palpated by the finger along the zygomatic arch In cases where the swelling has already subsided these irregularities are readily seen The mass of bone separated by these lines of fracture is usually driven into the antrum of Highmore and becomes impacted there"

Occasionally the injury is limited to the zygomatic arch, there being two lines of fracture in the arch, with a depressed fragment between This causes a visible and palpable hollow in front of the ear, crepitus may be present, and there is usually interference with the movements of the mandible from pressure on the underlying temporal muscle and coronoid process In an old case of this kind, seen by us, malunion resulted in fixation of the lower jaw due to callus and fibrous adhesions connecting the depressed zygomatic arch with the coronoid process

COMPLICATIONS OF FRACTURES OF THE MALAR BONE AND ZYGOMATIC ARCH

Again quoting Gillies, *et al* · "Situated in a region bounded by such structures as the eye, the antrum, the nose, and the infra-orbital nerve, a fracture, with such displacement as occurs in most cases, is liable to involve some or all of these important structures Such complications as nerve injury, eyeball injury, and involvement of the antrum or nose are quite common In the majority of cases the anterior wall of the antrum is crushed, and a suppurating hematoma may result It is essential that a careful watch be maintained for such an occurrence "

ROENTGEN-RAY DIAGNOSIS OF FRACTURE OF THE MALAR BONE AND ZYGOMATIC ARCH

The usual positions for obtaining radiographic films to show fracture lines and depressions of the bone in this region frequently give unsatisfactory results The technique suggested by Stone in the paper quoted is, in his opinion, superior to any previously used A supero-inferior view of the skull is made by having the patient rest the chin on the edge of the table, the tube being beneath the table and the plate on top of the head

To obtain the best view of the zygomatic arch, the head should not be placed symmetrically, but tilted slightly away from the injured side

Figure 183 gives a good radiographic view of a depressed fracture of the left malar bone, with pressure on the coronoid process. Figure 184 shows the same fracture after reduction and release of pressure on coronoid process of mandible

Figures 185 and 186 are radiographs of depressed fracture of right zygomatic arch, before and after reduction

TREATMENT OF FRACTURES OF THE MALAR BONE AND ZYGOMATIC ARCH

Depressed Fracture of the Body of the Malar Bone.—This consists in elevating the depressed bone to its normal position as soon after injury as possible When this is attempted during the first few days replacement is usually easy, but if the impaction is allowed to remain undisturbed for two weeks or longer it may be extremely difficult to move the displaced fragment and to retain it in normal position

The means suggested for elevating the depressed malar bone have been many, including digital manipulation from within the mouth, the use of



FIG 183 —Case II Radiograph showing depressed fracture of left malar bone with pressure on coronoid process (Dr Thomas P, Loughery) (Surg Clin North America, courtesy of W B Saunders Company)



FIG 184 —Case II Radiograph after reduction of malar fracture showing restoration of zygomatic arch and release of pressure on coronoid process of mandible (Surg Clin North America, courtesy of W B Saunders Company)

hooked forceps passed through the skin,[2] hooks, screws and elevators applied through external incisions,[5] and elevation through a heavy urethral

sound passed into the maxillary sinus through the canine fossa (Lothrop) or through an intranasal window[6] All of these methods have objections



Fig 185

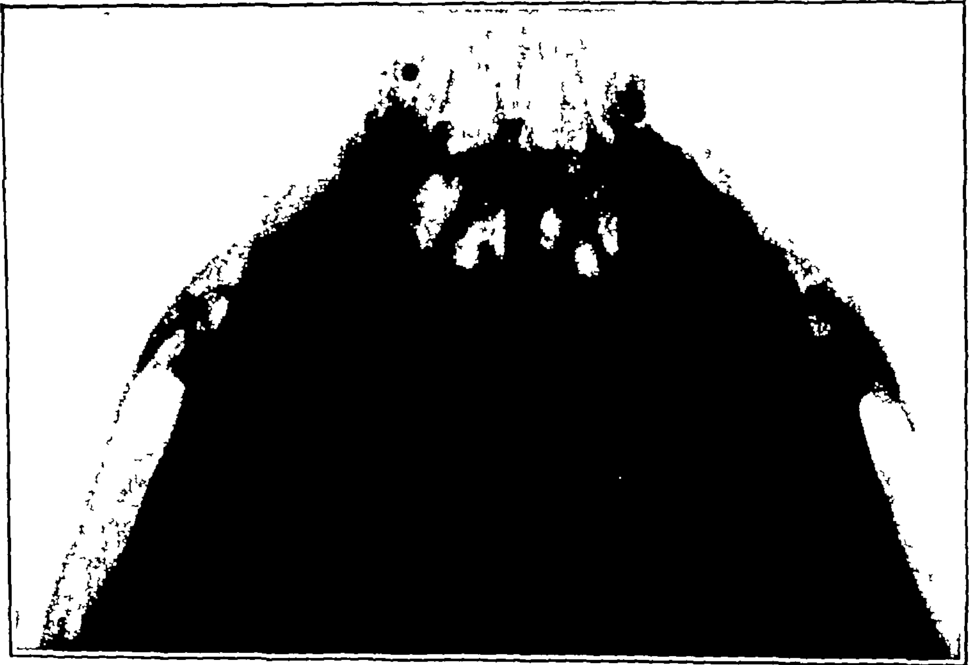


Fig 186

either because of inadequacy or on account of unnecessary scarring or danger of infection.

None of them has been so universally satisfactory in our hands during

the past seven years as that suggested by Gillies [3] It is much simpler than the written description would lead one to believe, can usually be carried out in five or ten minutes under nitrous oxide anesthesia and sufficient force can be applied to get results even where fairly firm union has occurred The hair over the temporal region on the affected side is shaved A skin incision 1 inch long is made obliquely forward and upward, beginning about 1 inch above and in front of the upper attachment of the ear With care the superficial temporal vessels are avoided, so that objectionable hemorrhage does not occur The skin edges are retracted, exposing the dense temporal fascia, which is slit sufficiently to admit a narrow bladed long elevator slightly angulated about 1 inch from its distal end

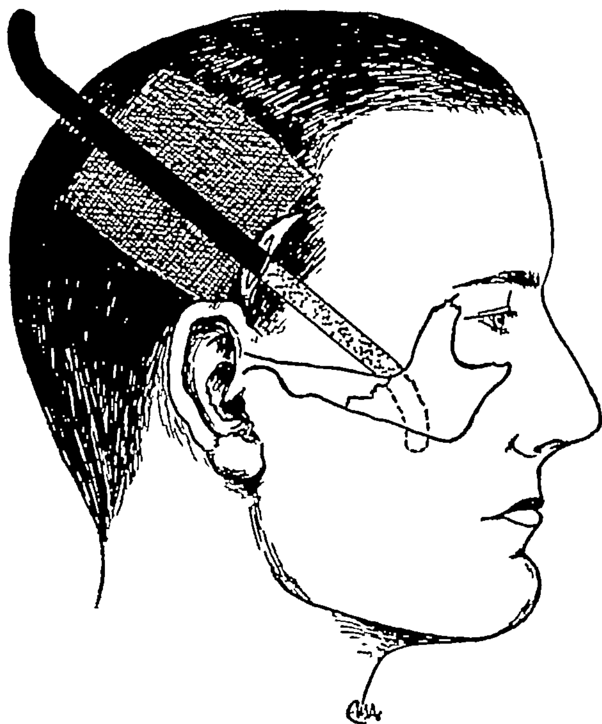


Fig 187 —Gillies' method of elevation of depressed malar bone (Brit Jour Surg)

(Fig 187) This elevator easily slides down beneath the fascia, on the surface of the temporal muscle under the malar bone, which can then be elevated to the desired position (Fig 187) In old cases, considerable force may be necessary to break up the adhesions After elevation, the malar bone usually remains in position without any special fixation. The skin incision is closed with horsehair sutures without drainage, and a pressure dressing applied with a bandage Healing is uneventful, and we have had no infection The scar, being above the hair line, is invisible. We do not advocate opening routinely into the maxillary sinus to drain the blood, as advised by some writers We have never had trouble from this cause Should signs of maxillary sinus infection occur, of course drainage would then be indicated.

The following report of cases is taken from an article published by us in the *Surgical Clinics of North America*, April, 1936, p 587

We have records of 10 cases of fracture of the malar bone during the past two years, in which elevation was performed by the method just described

Eight were males and 2 were females

The ages ranged from seventeen to forty-three years

The left side was involved in 7 cases, the right side in 3 cases

Cause	
Automobile accident	2
Struck by fist or blunt object	3
Struck by baseball	1
Collided playing football	1
Collided playing baseball	1
Collided playing basketball	2

The following is an analysis of the typical signs and symptoms:

A *depression of the cheek, subconjunctival and subcutaneous ecchymosis,* and *epistaxis* were observed in 10 cases

Numbness of the region supplied by the infraorbital nerve was complained of in 9 cases

Difficulty in closing the jaw was found in 4 cases

Diplopia was noticed in 3 cases

All cases except one were elevated one to four days after the injury In one case twenty-one days elapsed before the patient was seen

In all cases the cosmetic result was satisfactory The operation had no immediate effect on the numbness, which may persist for weeks, months or indefinitely In patients complaining of difficulty in closing the teeth, this disappeared immediately after the operation

The following is a brief description of 2 typical cases

CASE 1 —J K , male, aged twenty-four years, March 21, 1935, collided with another player during baseball game, left cheek being struck by back of other man's head Marked swelling of the soft tissues around the outer and lower part of the orbit, with subconjunctival and subcutaneous ecchymosis of lower eyelid, on left side Injury followed by profuse bleeding from left nostril When seen two days later there was a marked depression of the cheek below the outer canthus of the left eye, and tender points were palpable over the zygomatic arch and at the frontomalar junction as well as at the middle of the lower border of the orbit (Fig 180) Numbness over the infraorbital nerve distribution was noted March 23, under gas anesthesia, the depressed malar bone was elevated by Gillies' method Healing uneventful, sutures removed on fifth day. Figure 181 shows appearance of patient two weeks later.

CASE 2 —C B , male, aged forty years April 13, 1934, was in automobile accident, striking right cheek against framework of car At the hospital he suffered from slight cerebral concussion, which rapidly cleared up The right side of the face presented the typical swelling and flattening over the cheek bone He was unable to close his teeth completely, owing to some obstruction on the right side Roentgen-ray examination made in

the vertical position showed a depressed fracture of the right zygomatic arch and malar bone, impinging on the coronoid process of the mandible (Fig 183) April 17, under gas anesthesia the depressed right malar bone was elevated by Gillies' method This was followed by immediate disappearance of the jaw disability and restoration of the normal contour of the cheek Postoperative roentgen-ray examination showed zygomatic arch and malar replaced in good position (Fig 184)

Depressed Fracture Limited to the Zygomatic Arch.—For this form of fracture the method of Matas[4] is most efficacious A heavy curved needle is passed through the skin from above downward beneath the depressed fragment to emerge below the arch This needle is threaded with heavy silk, which in turn serves as a carrier for a piece of silver wire The two ends of the wire are twisted together and afford a means of traction on the bone fragment whereby it is elevated into position In case of tendency to recurrence, the wire is twisted over an ordinary glass microscopic slide whose ends rest on the firm portions of the bone Where there has been interference with the movements of the mandible gradual stretching can be obtained by use of the jaw exerciser previously described (p 104)

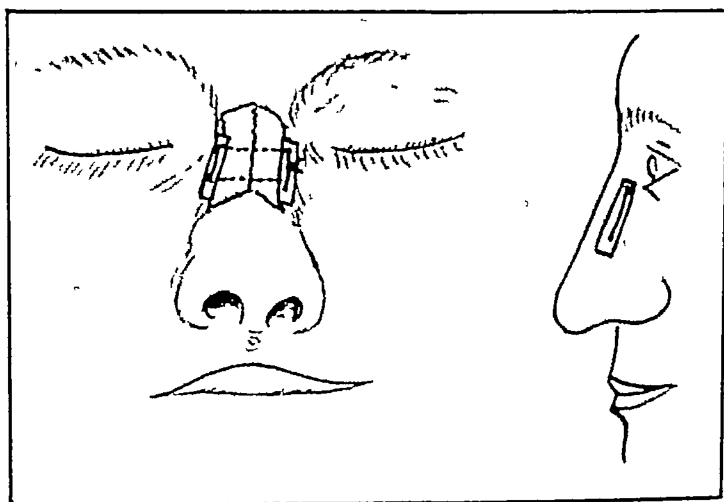


Fig 188

FRACTURES OF THE NASAL BONES

This is not the proper place for a detailed consideration of fractures of the nasal bones These, however, are so frequently associated with fractures of the jaws, that a few general remarks are indicated

The nasal bones may be thrust directly backward, with or without comminution, the septum being crushed or buckled beneath them, or the bones may be displaced to one side It is desirable to replace the fragments if possible before swelling masks the deformity, that is, within the first few hours after injury If postponed for two weeks or more union may require dislodgment with a chisel Fractures with little or no displacement do not require treatment In recent cases, it may be possible to elevate

the depressed bones by pushing them up with a closed pair of curved Kelly forceps inserted in the nostril and moulding with the fingers externally. The use of intranasal splints is not satisfactory as a rule, but the nose may be packed with gauze soaked in liquid petrolatum for twenty-four or forty-eight hours to maintain elevation and control hemorrhage.

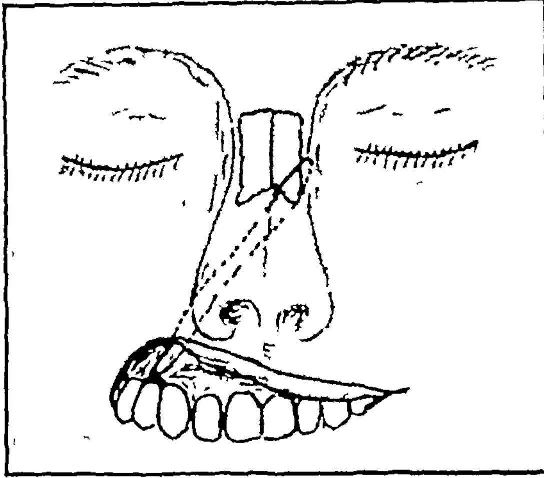


Fig 189



Fig 190 Fig 191

Where the nasal bones tend to sag down a mattress suture of fine wire or silkworm gut passed beneath them through the skin from side to side and tied over lead plates resting on the skin will often aid in preserving the prominence of the bridge (Fig 188) Recent cases with lateral deviation also can be corrected by manipulation, and recurrence of the deformity may be prevented by Blair's scheme of engaging the lower end of the nasal bone on the deviated side in a loop of fine wire passed through the skin, the ends being passed down across the septum into the vestibule of the

mouth on the opposite side and secured to a molar or premolar tooth (Fig 189) (See p 128) Figures 190 and 191 are before and after views of a patient treated by this method

Many times, in spite of early treatment, it is impossible to reduce the displacement completely, and a secondary deformity results, requiring later correction

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CHAPTER VII

ROENTGENOGRAPHIC TECHNIQUE

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The roentgenogram is an indispensable factor in the examination of maxillary and mandibular fractures But to have the fullest use of this important aid, much depends upon the experience and thoroughness of the roentgenologist, for in the study of these fractures it is just as essential that a definite and comprehensive technique be followed as it is when examining sinuses Dire results have too often followed failure to know and to abide by the routine of proper technique

Two techniques must be known and followed the intra-oral technique and the extra-oral technique The region under examination determines the technique the operator should follow, and determines also the type of film to be used All examinations are made with the patient in the sitting posture

The *extra-oral technique* is employed when fracture is suspected in the following regions

Condyloid process
Ramus
Coronoid process
Body of the mandible, extending from canine region to angle
Maxilla (general survey)
Malar bone
Zygomatic arch

The *intra-oral technique* is employed in examination for suspected fracture of the following

Symphysis of the mandible
Buccal and lingual plates of the mandible
The maxilla

In the development of a definite technique, we employ the two accepted planes of the head—the sagittal plane, around which the extra-oral technique has been built, and the occlusal plane, with which the intra-oral technique is more closely associated And here it may be stated generally that in following the extra-oral method the type film used is either a 5 x 7 inch or an 8 x 10 inch duplitized film, used always with double intensifying screens placed in a suitable cassette But for the intra-oral method it is necessary to use the Eastman occlusal film, 2 x 3 inches, which is placed in the mouth parallel with the plane of occlusion and held in that position by the bite of the patient upon the film packet

EXTRA-ORAL TECHNIQUE

For all extra-oral exposures a target-plate distance of 36 inches is used, with a 5 inch spark gap and 10 milliamperes of current

For roentgenographic studies of the *condyloid process and the temporomandibular articulation,* the definite progressive steps to be followed are

An 8 x 10 cassette loaded with film is placed perpendicular to the floor

The sagittal plane of the head is adjusted parallel with the plane of the cassette (Fig 192) The lateral tilt of the head is determined by placing head in such a position that an imaginary line drawn from the condyle of the side under examination to the gonion of the mandible of the opposite side, is parallel to the floor (Fig 192)

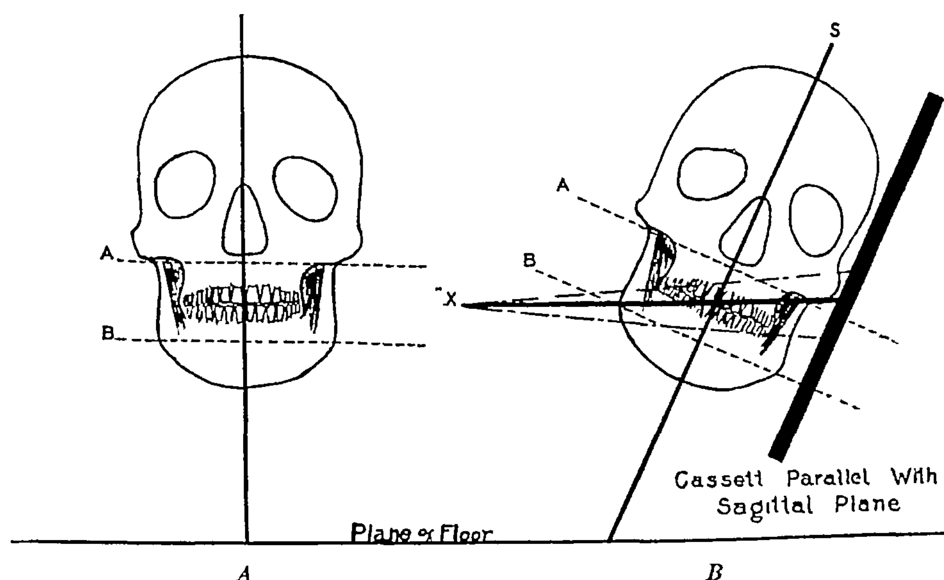


FIG 192—*A*, The sagittal plane of the head is perpendicular to the floor The line —*A*— is an imaginary line drawn through the condyles of the right and left side of the head and perpendicular to the sagittal plane The line —*B*— passes through the gonion of the right and left mandible and is perpendicular to the sagittal plane *B*, The sagittal plane of the head being parallel with the plane of the cassette, the head is tilted with the cassette until the imaginary line —*X*—, which is a line drawn from the condyle of the affected side to the gonion of the mandible nearest the tube, is parallel with the floor When this is accomplished the head is in the proper lateral position The roentgen-rays should follow the line —*X*—

The head of the patient is then extended forward as far as possible, this is highly important as extension of the head brings the temporomandibular articulation anterior to the cervical vertebræ, thus avoiding superimposition of the shadow of the vertebræ over the temporomandibular articulation and the condyloid process (Fig 193)

A 2-inch bandage is passed around the head of the patient and the cassette, and fastened by a clamp or hemostatic forceps (Fig 194) to prevent mobility of the head This detail is extremely important, for the slightest movement between the object and the film during exposure to the roentgen-rays would produce a blurred, and therefore a useless, image.

In order that the central rays may pass in front of the vertebræ and through the condyloid process of the opposite side of the head, the tube is

then moved anteriorly in a horizontal plane, and the central rays directed at the gonion of the mandible nearest the tube (Fig 193) at an angle of 5 degrees from the perpendicular, the rays, however, remaining parallel with the floor (Fig 194)



Fig 193 —Illustrating the point of entry for the central rays, when making extra-oral roentgenograms of the mandible (Ennis)

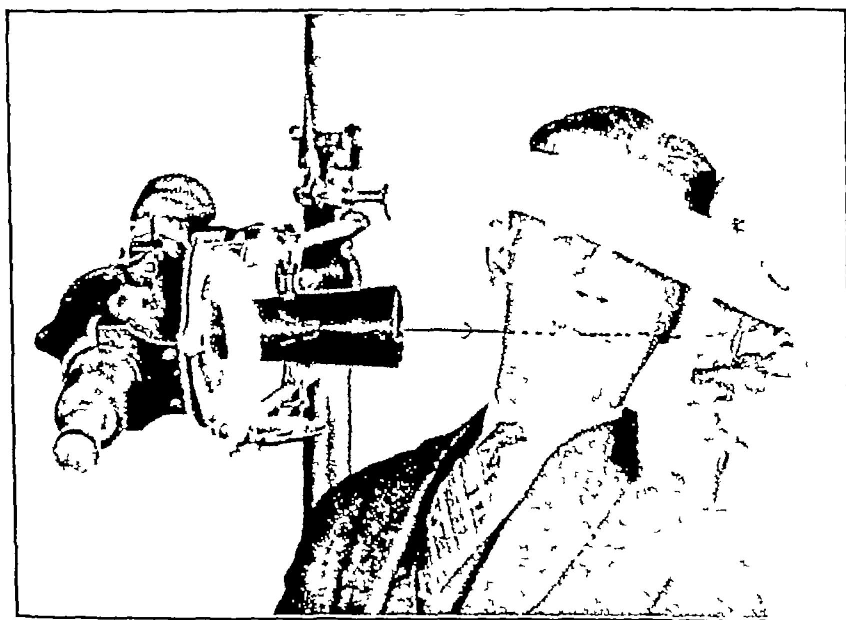


Fig 194 —Illustrating the relationship between the plane of the cassette, the sagittal plane, and the position of the tube, for fractures of the condyloid process (Ennis)

If the operator follows the technique as outlined, the results should be similar to those shown in Figures 195, 196 and 197.

In making roentgenographic studies of the *body of the mandible* extending from the canine region to the angle, some features of the technique just outlined are used:

The sagittal plane of the head and the plane of the cassette must parallel each other

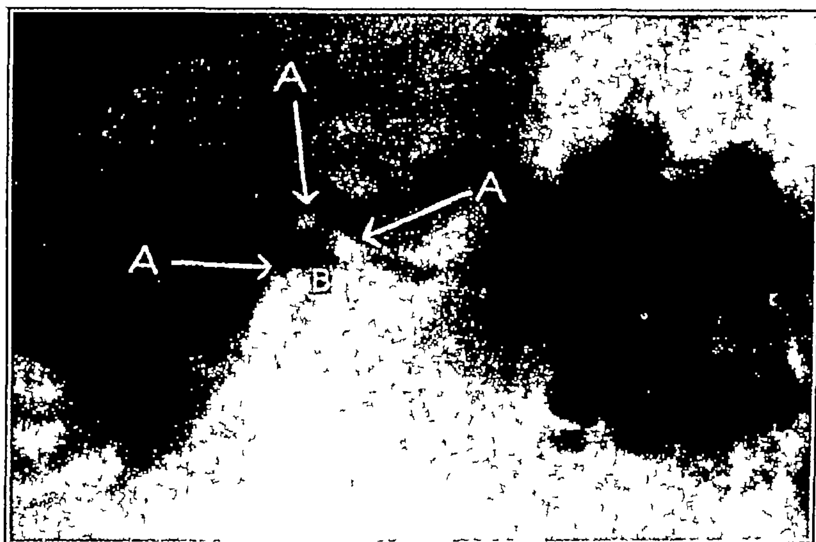


FIG 195 —Roentgenogram illustrating the relationship between the glenoid fossa *A*, and the condyloid process of the mandible, *B*, forming the temporomandibular articulation

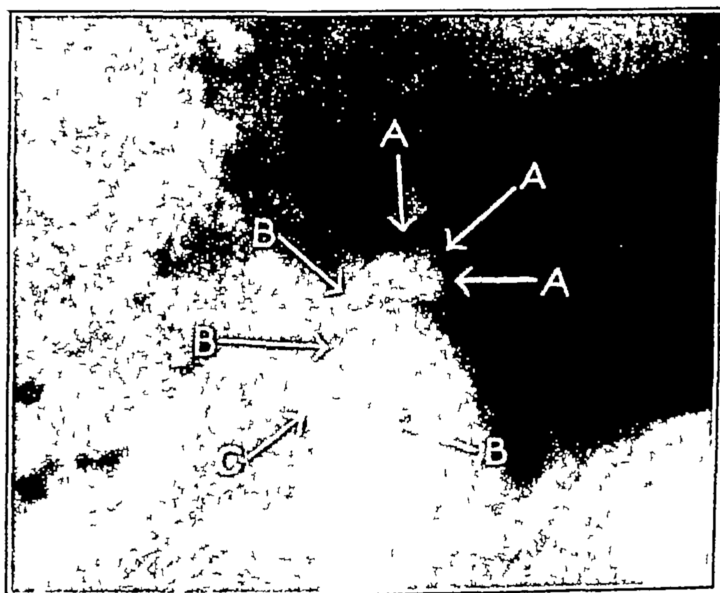


FIG 196 —Fracture of the neck of the condyloid process *A*, the glenoid fossa, *B*, the condyloid process pulled downward and forward, *C*, the line of fracture

The head of the patient and the cassette must be inclined away from the tube at an angle of 30 degrees from a perpendicular to the floor.

The head must be extended anteriorly as far as possible

But at this stage it is necessary to consider well the posture of the head before it is bound to the cassette so as to prevent mobility.

The sagittal plane of the head is rotated toward the plane of the cassette until the long axis of the mandible is parallel with the plane of the cassette, and when in this position the malar bone and the zygomatic process, with the body of the mandible, will be in contact with the cassette (Fig 198).



Fig 197 —Fracture of the condyloid process Arrows *A* pointing to the rotated condyloid process *B*

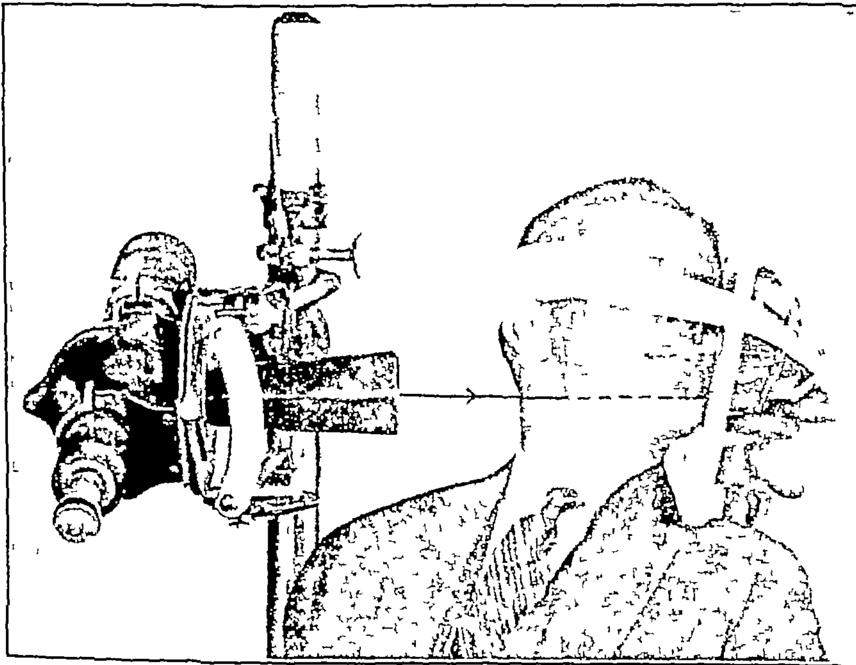


Fig 198 —Illustrating the relationship between the plane of the cassette, the sagittal plane, and the position of the tube, in examination for fractures of the body of the mandible (Ennis)

This position attained, a 2-inch bandage is passed around the head an cassette, binding them together to prevent even the slightest movemen between them

Adjusting the plane of the cassette perpendicular to the floor, the tube is placed so that the central rays will be perpendicular to the cassette in both the horizontal and vertical planes

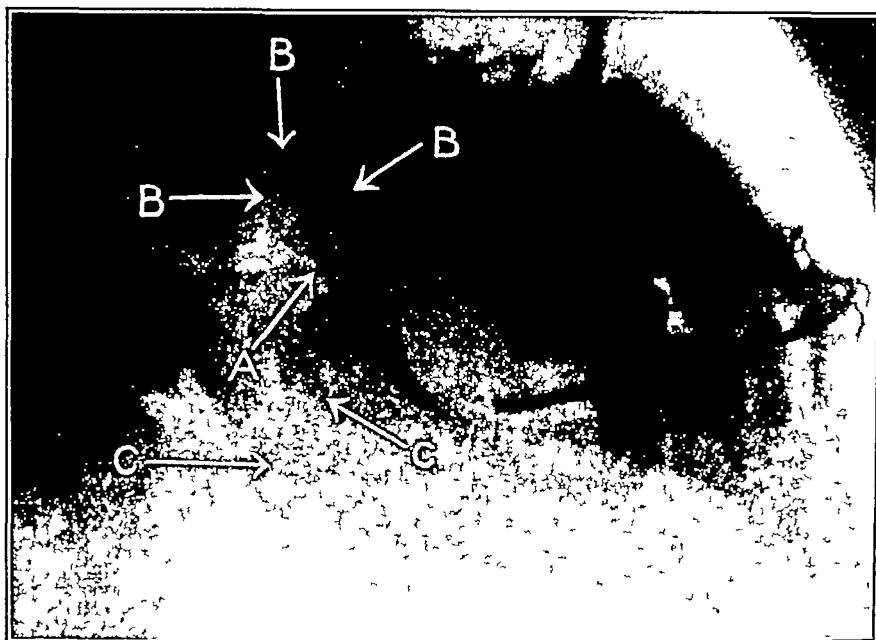


Fig 199 —Arrows *B* pointing to fracture of the coronoid process, *A*, line of fracture, *C*, line of fracture extending from the angle of the mandible to the line of fracture of the coronoid process



Fig 200 —*A*, illustrating the extreme anterior region that may be examined by this technique, *B*, line of fracture posterior to the third molar through the angle of the mandible

Now, while the tube remains in this position the head and the cassette are inclined at an angle of 30 degrees from a perpendicular to the floor

Thus the vertical angulation, or the angle formed between the central rays and the plane of the cassette, becomes 120 degrees, while the horizontal angulation of the tube remains at 90 degrees (Fig 198).

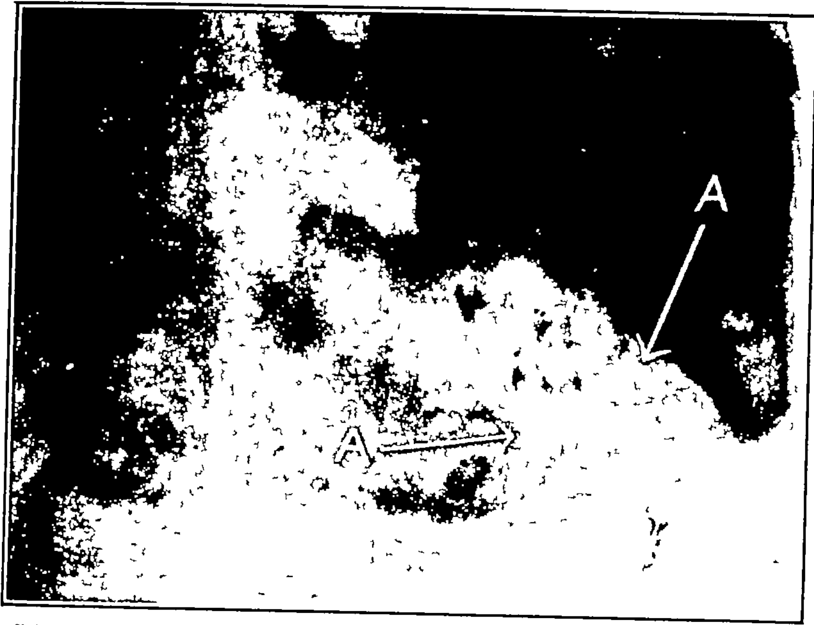


Fig 201 —Illustrating a fracture in the region of the premolars with a large sequestrum in the line of fracture

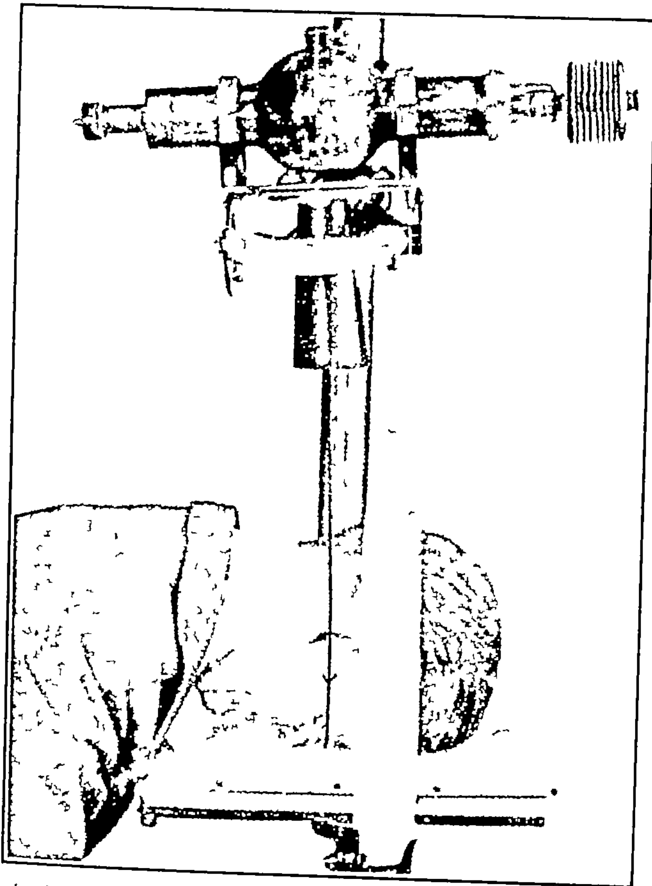


Fig 202 —Illustrating the relationship between the plane of the cassette, the sagittal plane of the head, and the position of the tube, in examination for fractures of the ramus of the mandible, and also for a general survey in suspected fractures of the maxillæ (Ennis)

then directed perpendicular to the plane of occlusion, parallel with the sagittal plane, but through the temporomandibular articulation and parallel to the posterior border of the ramus, giving the result seen in Figure 205 By slightly varying the technique used for the vertical view of the temporomandibular articulation we are able to locate the depressed fractures of the malar bone The technique is the same as shown in Figure 204 with the following exception The rays are directed downward, paralleling the plane of the face and paralleling the sagittal plane, through the area of suspected fracture Giving a result as seen in Figure 206

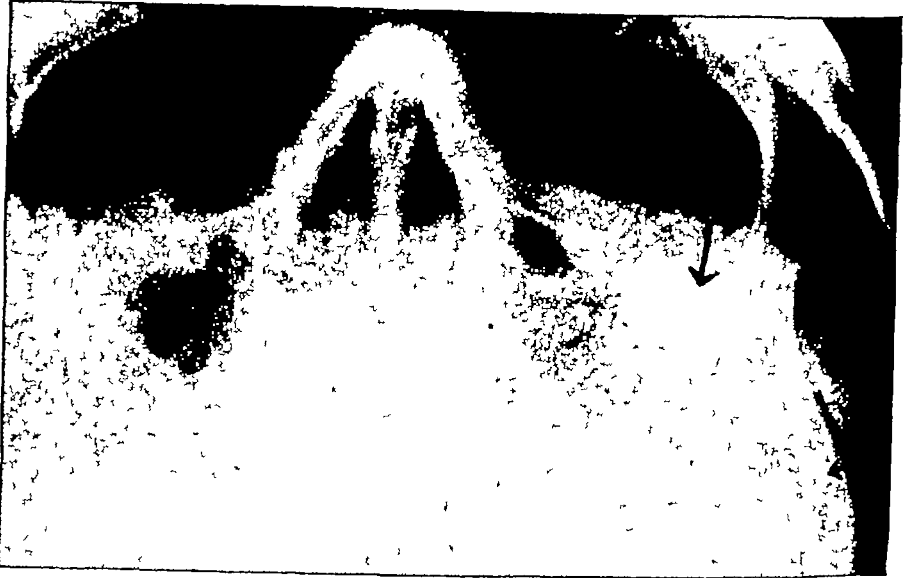


FIG 206 —Roentgenogram revealing the zygomatic arch and malar process

INTRA-ORAL TECHNIQUE

While the majority of fractures of the jaws are found in the mandible, the number of maxillary fractures seems to be on the increase, and they are difficult to reveal in the roentgenogram without precise technique

Fractures of the Symphysis of the Mandible —When studying fractures in the region of the symphysis of the mandible, it is necessary to employ the intra-oral technique, effective because of the simplicity and the rapidity with which results are obtained, and, highly important, because the superimposition of other anatomical structures is completely avoided

The technique follows The patient should be in a sitting posture where possible, with the head resting comfortably in the headrest, the sagittal plane of the head perpendicular to the floor, and the head inclined backward with the occlusal plane at an angle of 40 degrees to the plane of the floor

An Eastman occlusal film, the corners of the film packet first bent under to avoid discomfort to the patient, is inserted into the mouth as far as possible with the smooth side of the film packet—the emulsion side of the film—toward the tongue and paralleling the plane of occlusion. It is held in position by the bite of the patient

The tube is then adjusted so that the central rays parallel the sagittal plane and pass through the symphysis at an angle of 15 degrees, making the total angle between the plane of the film and the central rays 60 degrees (Fig 207), and giving the results as seen in Figures 208, 209, 210, 211, 212 and 213

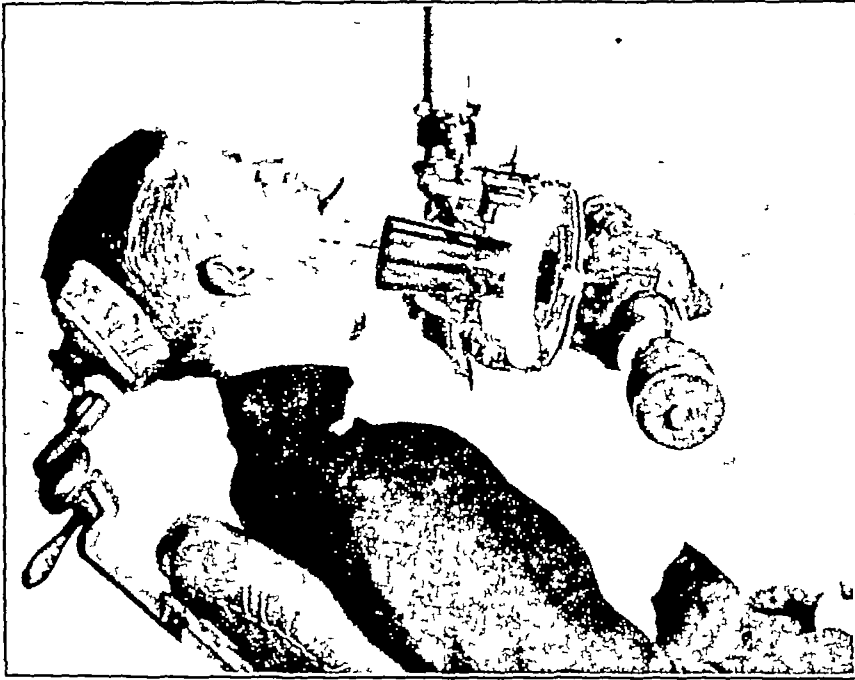


FIG 207 —Illustrating position of tube and patient in examination for fractures of symphysis



FIG 208 —Fracture of the symphysis taken at an angle of 70 degrees (Ennis)

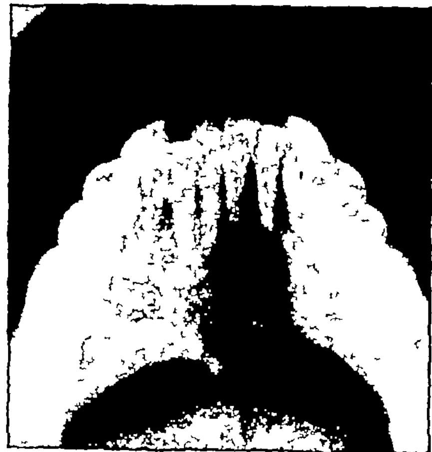


FIG 209 —Same case as Figure 208, only taken at an angle of 60 degrees (Ennis)

For suspected *fractures of the buccal or lingual plates of the mandible*· With the head of the patient in the headrest, the chin is inclined backward until the patient is reclining with the sagittal plane of the head perpendicular to the floor, with the chin extended upward and forward until the occlusal plane is also perpendicular to the floor (Fig 214)

The occlusal film, the smooth or emulsion side next to the tongue, is then inserted into the mouth in the occlusal plane, the patient being instructed to bite upon it to hold it in position. The tube is thereupon angulated so as to have the central rays parallel to the sagittal plane and perpendicular to the occlusal plane and directed through the suspected area (Fig 214) The results should be as shown in Figures 215 and 216

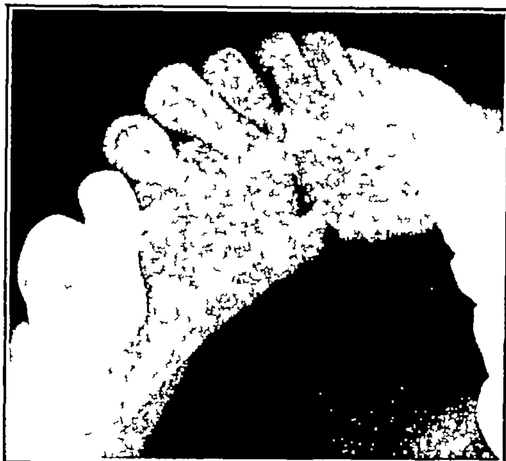


Fig 210 —Fracture of the mandible showing line of fracture between the first and second incisors



Fig 211 —Illustrating line of fracture between second incisor and canine



Fig 212 —Illustrating an oblique fracture in the canine region



Fig 213 —Illustrating a comminuted fracture in the region of the symphysis

In examining *fractures of the maxilla* the patient should be in a sitting posture, the head lying comfortably in the headrest, the sagittal plane of the head perpendicular to the floor and the occlusal plane parallel to the floor

An occlusal film is inserted into the mouth with the smooth or emulsion side of the packet toward the palate and paralleling the plane of occlusion, and held in that position by the patient biting upon the packet (Fig 217). The tube is thereupon adjusted so that the central rays will be at a

vertical angle of 60 degrees and will be parallel to the sagittal plane (Fig 217)

This method of examination will reveal the anterior portion of the maxilla as illustrated in Figure 218

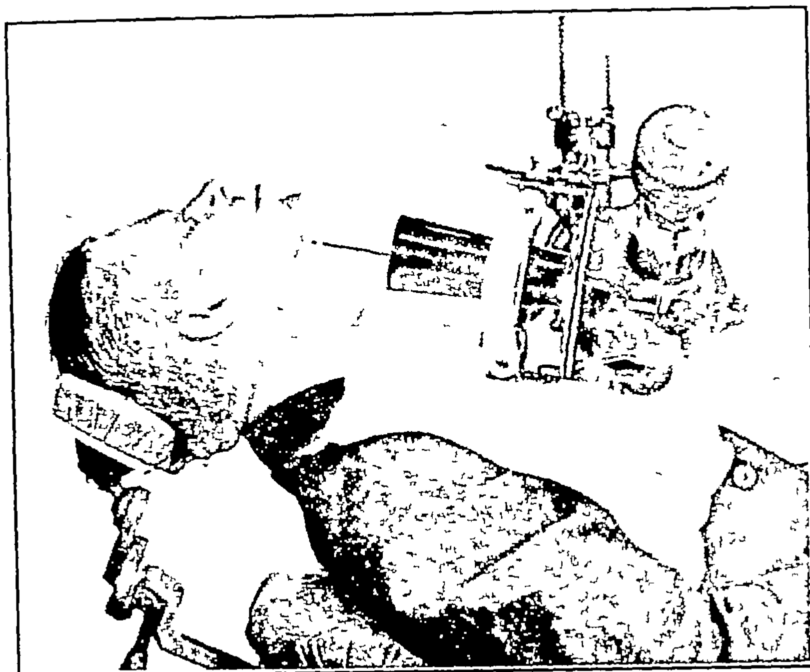


Fig 214 —Illustrating the position of the tube and patient for fractures of the buccal or lingual plates of the mandible (Ennis)

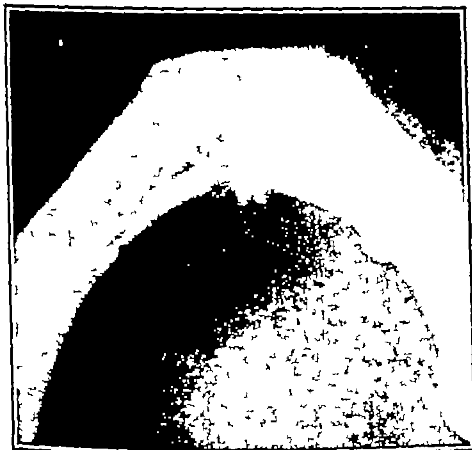


Fig 215 —Illustrating a fracture of the lingual plate of the mandible



Fig 216 —Illustrating an oblique fracture of the mandible

For *fractures in the molar and premolar regions of the maxilla,* the position of the patient and the film is the same as when making roentgenographic studies of the anterior region of the maxilla—patient sitting, head in head-rest, sagittal plane perpendicular to t[illegible] occlusal plane parallel to

floor, and an occlusal film is inserted parallel with the plane of occlusion, the emulsion side facing the palate, and held in position by the bite of the patient

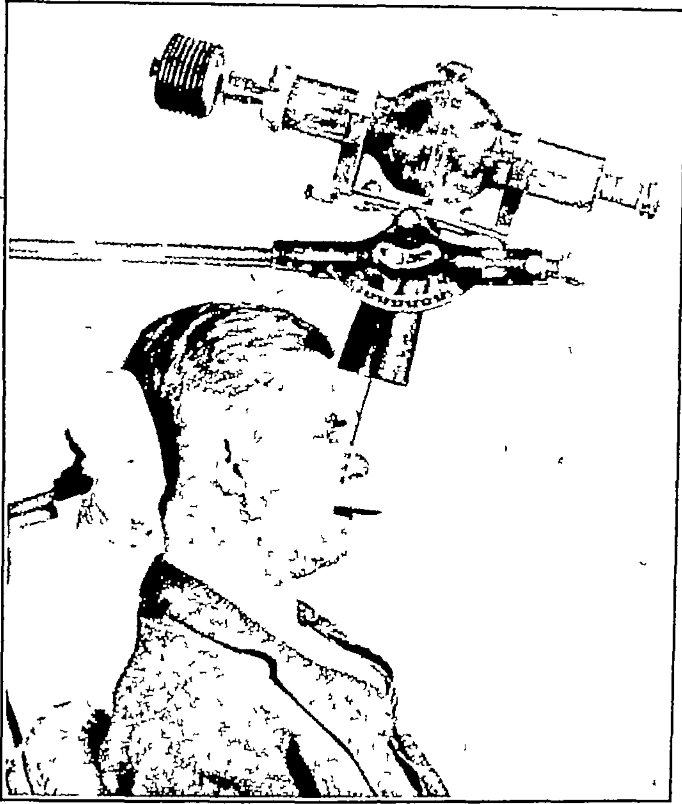


Fig 217 —Illustrating relationship between the film, the patient and the tube in examination for fractures of the anterior portion of the maxilla (Ennis)



Fig 218 —Illustrating a fracture of the anterior portion of the maxilla

The tube is placed to allow the central rays to pass through the premolars at a horizontal angle of 45 degrees from the sagittal plane and at a vertical angle of 50 degrees from the occlusal plane (Fig 219)

An adherence to this technique should produce a result as presented in Figure 220

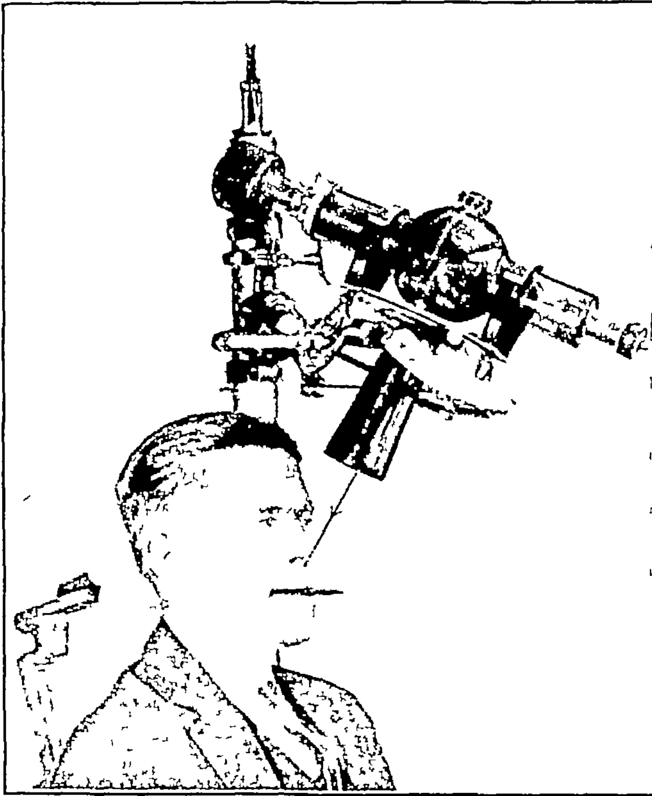


FIG 219 —Illustrating the position or relationship of the tube to the occlusal plane and film in examination for fractures of the molar and premolar regions of the maxilla (Ennis)



FIG 220 —Showing a fracture of the maxilla in the premolar region, the fragment being driven into the maxillary sinus

CHAPTER VIII

DIETARY MANAGEMENT IN FRACTURES OF THE JAWS

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THERE is an intimate connection between the region of the mouth and body metabolism, and the latter may be vitally altered if the patient is temporarily deprived of his masticatory powers, rendering impossible the proper mechanical preparation of his food for digestion and assimilation In dealing with a fracture somewhere else in the body, a femur, for example, this condition would not be a factor

Dietary management in injuries of the jaws is often a factor that is neglected to such an extent that patients steadily lose weight, become discouraged and fail to cooperate Nothing is more ruinous to a patient's morale than to be continually hungry or to be forced to subsist on the same liquid diet day after day

There are certain fundamental principles which apply to all diets It is not within the scope of this chapter to review these facts, other than to mention that a normal diet contains approximately four times as much carbohydrate material as protein or fats, and must contain such foods as will supply an alkaline ash The carbohydrate content may be varied according to the activity of the patient, and with due regard for the interference in carbohydrate digestion often presented by these patients

Healthy individuals must eat ample quantities of certain foods if they wish to remain well, and the basic principles of diet must not be violated even when illness or injury demands special nutriment A properly balanced diet will keep the patient in comfort and maintain his weight to a large degree It has been found, for instance, that patients with simple mandibular fractures retained by intermaxillary fixation will lose weight at first but will regain their normal weight within a few weeks and are often heavier upon termination of treatment than upon admission

The diet should have a high nutritional value (caloric) yet should avoid foods tending to constipation The normal diet should contain ample calories The number of calories required varies according to age, sex and more especially with regard to the extent of body surface of the patient It will be understood, though, that each patient requires individual attention and adaptation of the diet to fit his needs But, with this understanding, the following table will be useful as showing the number of calories daily required for average cases

1500 to 1800 Calories for bed patients
1800 to 2000 Calories for invalid patients
2000 to 3000 Calories for active patients

In general, the diet should be relatively high in proteins and fats, and low in carbohydrate content There is no active digestion of any foods

except carbohydrates in the oral cavity Foods not masticated but merely swallowed cannot receive much ptyalic reduction Meats are merely mechanically prepared in the oral cavity This preparation must be done for these patients so that this type of protein can be readily digested

A variety of food is a necessity Anyone will tire quickly of even his favorite food if it is served to him three times daily Therefore, an attempt must be made to maintain a diversified as well as a balanced diet

The food should be well cooked, which includes proper seasoning The patient should be supplied with condiments so that he may season the food to his individual taste It should be served in an appetizing manner It must appeal to the eye, must be enjoyable as well as nutritious Such nourishment as is intended to be served hot should be *hot,* not lukewarm The same applies to cold foods and beverages

All nourishment must be so prepared that it may be taken by the patient regardless of the type or location of his injury or operation From practical clinical experience, it has been found that the dietary management of these cases can best be accomplished in larger hospitals by having two standard "Jaw diets "

Liquid Jaw Diet—based upon 2000 to 2500 Calories
Soft Jaw Diet—based upon 2500 to 3000 Calories.

Limiting the number of diets simplifies the food preparation and the serving, and so reduces the amount of supervision to a minimum.

In the smaller hospitals, particularly those not employing trained dietitians, and in the home, the surgeon must take a more active part in feeding his patients Those not specially trained cannot be expected to cope with these special cases until they have had some instruction in the rudiments of this type of dietary management.

It will be found that written instructions with a *list* from which to choose foods and a *sample daily diet* will simplify the problem

METHODS OF FEEDING

The following are the methods ordinarily used in feeding cases of fracture of the jaws

1 Drinking tube feeding
2 Cup or bowl feeding
3 Spoon feeding

Naso-pharyngeal feeding and rectal feeding may be used in exceptional cases

The removal of normal teeth for the purpose of feeding is not to be countenanced In uncomplicated cases nourishment is sipped between and around the teeth Spaces remaining from former extractions are utilized to the utmost Patients with a full complement of teeth can take nutriment with facility

1 **Drinking Tubes (Sippers).**—*For Liquid Diet* —This method is useful where there is a continuity of the buccal orifice, the cheeks, the floor of the mouth, the palate and the uvula, the tongue must be functional, and

there must be sufficient space between the dentitions for the entrance of the tube into the mouth so the tongue can be placed against the end of the tube Glass tubing should be as large as can be used comfortably The proximal end should be slightly flattened Straws, such as are used at soda fountains, may be used in emergencies, but are rather unsatisfactory This method of feeding is efficient in intermaxillary fixation cases where there are teeth missing in the anterior part of the mouth

2 **Cup and Bowl Feeding.**—*For Liquid or Soft Diet* —This is the most useful method for routine use If the patient has functional lips and cheeks, he soon learns to feed himself by using soups and broths as the vehicle for the more solid portions of the diet In this connection the feeding problem should be kept in mind when planning and constructing the appliances Kingsley arms, etc , should always be indented into the *upper* lip a few millimeters from the angle of the mouth so the patient can execute sucking movements without drooling No appliances should interfere with the action of the upper lip in the mid-line, as it is very difficult for the patient to be nourished by the ordinary means if this factor has been overlooked

3. **Spoon Feeding.** (Active or Passive)—*For Liquid or Soft Diets* —The size of the spoon must be governed by the case at hand. This method is valuable in those cases where there is loss of continuity of the buccal orifice making it impossible to use drinking tubes or bowls This method must be used when the patient's arms are not functional

4 **Naso-pharyngeal Feeding.**—*For Liquid Diet* —A slightly lubricated catheter of suitable size is passed through the nostril having the greater space and advanced until the tip is below the uvula and in the oropharynx Liquids are placed in a funnel or irrigator The patient soon learns to signal as to the quantity and rate, or to handle the intake by compression of the catheter with his fingers This method is useful in serious cases with extensive comminution and tissue loss, especially of the mandible and floor of the mouth

5 **Rectal Feeding.**—*Liquid Nourishment* —This method is resorted to only in very serious cases wherein there is inability to swallow, the patient unconscious or in shock

LIQUID DIET FOR JAW CASES

This diet list is intended to serve as a basis from which to choose daily diets for patients for whom an absolutely liquid diet is necessary These will include maxillary and mandibular fracture cases which are retained by intermaxillary wiring or splints

Fruits

Apple sauce (purée)
Scraped apple
Purée* of peaches, pears, apricots, fresh or canned, prunes, cantaloupe

* *To purée* Vegetables and dried fruits Cook till well done Rub through a purée sieve (75 holes to a square inch) with the back of a spoon Fresh or canned fruits may be mashed and rubbed through a purée sieve

Cereals All cereal gruels such as cream of wheat, wheatena, grits, corn meals, thinned with milk or cream

Soups (strained) Cream soups, vegetable soups, chowders, broths (beef or chicken), beef juice, beef tea, oyster stew, clam broth

Vegetables (purée very fine) Tomatoes, carrots, beets, cauliflower, string beans (fresh or dried), lima beans, asparagus, squash, turnips, celery, spinach, peas, mashed potatoes, mashed sweet potatoes

Meats Finely ground and sieved meats, scraped beef, liver cocktail (calves', beef or chicken liver)

Desserts Ice cream (without nuts or fruit), sherbets and ices, soft custards (caramel, chocolate, etc), junkets, plain jello, thin cornstarch pudding

Beverages Cocoa or chocolate, cocoa malt, chocolate milk, tea (iced in summer), milk, malted milk, half and half (milk and cream), egg nogs, coffee or substitute (iced in summer), lemonade, orangeade, grape juice

LIQUID DIET FOR JAW CASES

A sample balanced diet for one day (2000 to 2500 Calories)

		Calories	
Breakfast			
Orange juice	1 glass	100	
Cream of wheat	¾ cup	100	
Cream	40 grams	75	
Cocoa	1 cup	300	
		——	575
10 A M			
Egg nog	1 glass	200	
Dinner			
Cream of celery soup	1 cup	160	
Add to soup			
Beef, finely ground	1 tablespoonful	130	
Purée of sweet potato	1 potato	135	
Purée of spinach	½ cup	25	
Milk* to thin potatoes and spinach	80 grams	55	
Boiled custard	1 cup	300	
Tea, with 40 grams cream	1 cup	75	
		——	880
Supper			
Chicken broth	1 cup	100	
Add to broth			
Mashed potatoes	½ cup	50	
Purée of carrots	2 carrots	45	
Milk to thin potatoes and carrots	80 grams	55	
Purée of fresh peaches	3 med peaches	100	
Cocoa	1 cup	300	
		——	650
8 P M			
Grape juice	1 glass		200
Total			2505

* Milk is an entirely satisfactory food beverage for these cases

SOFT DIET FOR JAW CASES

In certain types of cases of fracture of the jaws where intermaxillary fixation is not used, or where there is sufficient intermaxillary space, the extreme liquid form of diet may be modified

Fruits (juice and pulp) Baked apples, apple sauce, bananas (fresh and

baked), oranges, grapefruit, stewed prunes, stewed apricots, stewed figs, stewed peaches, rhubarb, grapes, ripe cantaloupe, ripe watermelon

Canned fruits Pears, peaches, apricots, crushed pineapple, cherries

Cereals All cooked cereals oatmeal, wheatena, cream of wheat, corn meal, Pettijohns, grit.

Soups. Cream soups, strained vegetable soups, broths, beef tea, beef juice

Vegetables (purée) Tomatoes, carrots, cauliflower, beets, string beans, lima beans, asparagus, squash, baked eggplant, turnips, celery, spinach, mashed or baked potatoes, baked sweet potatoes Use milk and butter liberally in preparation

Eggs Soft boiled, scrambled, poached, omelette

Milk toast Fresh bread, purée of rice, spaghetti, macaroni, noodles

Meats Oysters, clams, brains, sweetbreads, creamed chicken, baked or boiled fish, ground meat and gravy

Desserts Ice cream (without nuts or fruits), sherbets and ices, plain jello, custard (baked or soft), junket, rice, tapioca and brown betty puddings

Beverages Milk, malted milk, buttermilk, cocoa, cocoa malt, coffee or substitute (iced in summer), tea (iced in summer), orange juice, grape juice, grapefruit juice

All foods to be of a physically soft character

SOFT DIET FOR JAW CASES

A sample balanced diet for one day (2500 to 3000 Calories)

		Calories	
Breakfast			
Baked apple	1 apple	200	
Wheatena	½ cup	75	
Cream	40 grams	75	
Eggs	1 poached	85	
Coffee with cream	1 cup	75	
		——	510
10 A M			
Malted milk	1 cup		200
Dinner			
Cream of asparagus soup	1 cup	200	
Baked potato with 20 grams butter	1 potato	250	
Purée of beets	2 beets	50	
Mashed turnips	½ cup	150	
Vanilla ice cream	1 portion	200	
Cocoa	1 cup	300	
		——	1150
Supper			
Cream of tomato soup	½ cup	100	
Mashed potato	1 cup	50	
Ground lamb	80 grams	150	
Purée of peas	½ cup	120	
Tapioca cream	1 cup	255	
Tea with 40 grams cream	1 cup	75	
		——	750
8 P M			
Orange juice	1 glass		100
Total			2710

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